Southwest
FISHERIES SCIENCE CENTER

HONOLULU LA JOLLA MONTEREY TIBURON

REPORT OF ACTIVITIES January-February 1991

ANTARCTIC ECOSYSTEM RESEARCH GROUP Page
First Leg of 1991 AMLR Cruise Completed 1

COASTAL FISHERIES RESOURCES DIVISION
Southwest Region Economists Meet 6

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION
Marine Mammal Observers Return from Acoustic Global Warming Feasibility Experiment 8

HONOLULU LABORATORY
Scientists Conduct Swordfish Longline Research Cruise 16

PACIFIC FISHERIES ENVIRONMENTAL GROUP
Co-occurrence of Elevated Temperatures in the California Current Region and Tropical El Niño-Southern Oscillation Activity 19

PELAGIC FISHERIES RESOURCES DIVISION
Comparison Made of U.S. Eastern Tropical Pacific Tuna Purse Seine Day and Night Set Mortality Rates 20

TIBURON LABORATORY
Study Indicates Problems with Coastwide Trip Limits in Lingcod Management 24

INFORMATION TECHNOLOGY SERVICES
Conversion of Financial Reporting System to 3COM LAN 25

PUBLICATIONS 26

SOUTHWEST FISHERIES SCIENCE CENTER

CENTER ADMINISTRATION- La Jolla, California

Science and Research Director, SWR ..... *Izadore Barrett*
Deputy Director ..... *Richard A. Neal*
Planning Officer ..... *David J. Mackett*
Information Technology Services ..... *Dorothy Roll*
Executive Officer ..... *Benjamin F. Remington*

LABORATORIES & DIVISIONS

Antarctic Ecosystem Research Group, Chief ..... *Rennie Holt*
La Jolla, California
Coastal Fisheries Resources Division, Chief ..... *John R. Hunter*
La Jolla, California
Fishery-Marine Mammal Interactions Division, Chief ..... *Douglas P. DeMaster*
La Jolla, California
Honolulu Laboratory, Director ..... *George W. Boehlert*
Honolulu, Hawaii
Pelagic Fisheries Resources Division, Chief ..... *Gary T. Sakagawa*
La Jolla, California
Pacific Fisheries Environmental Group, Chief ..... *Andrew Bakun*
Monterey, California
Tiburon Laboratory, Director ..... *Alec MacCall*
Tiburon, California

The Report of Activities of the Southwest Fisheries Science Center is compiled at La Jolla from material submitted by the Center's staff. To change the delivery address of the Report of Activities, or to cancel your subscription, please notify Lorraine C. Prescott , at P.O. Box 271, La Jolla, CA 92038. Telephone: (619) 546-7063.

ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

First Leg of 1991 AMLR Cruise Completed

The NOAA Ship *Surveyor* departed Punta Arenas, Chile on January 16, 1991, to begin Leg I of the Antarctic Marine Living Resources (AMLR) program's annual research cruise in the waters surrounding Elephant Island, Antarctica. During the ship's transit across the Drake Passage, a series of expendable bathythermograph (XBT) observations were conducted by a Chilean scientist. On the morning of January 19, the *Surveyor* arrived at Seal Island, a small island next to Elephant Island, and off-loaded scientific equipment and provisions to an AMLR field team stationed there since early December 1990. AMLR Chief Rennie Holt was also transported to the island to take part in land-based research activities.

After the ship left Seal Island, acoustic systems used to map the distribution of krill, *Euphausia superba*, were successfully calibrated in Ezcurra Inlet, off Admiralty Bay, King George Island. During the calibration, several members of the scientific party and the ship's crew visited the Polish research base, Arctowski, on King George Island.

On January 21, scientists aboard the *Surveyor* began a broad survey around Elephant Island, Clarence Island, and the east end of King George Island, to map the major features of krill distribution, primary production, and water masses. Despite rough seas, over 1,100 miles of acoustic transects were conducted and 50 conductivity-temperature-depth (CTD)/rosette and net sampling stations were occupied. Through the coordinated efforts of Roger Hewitt (AERG) and Michael Macaulay (University of Washington), two acoustic systems were deployed to survey for krill, which were found sparsely distributed over most of the survey area. Higher densities were observed, however, nearshore on the south and north sides of King George Island, along the shelf break north of Elephant Island, and in deeper water approximately 30 miles northeast of Elephant Island.

In association with net sampling studies conducted by Valerie Loeb (Moss Landing Marine Laboratories) and John Wormuth (Texas A & M University), krill were collected at 36 of the 50 CTD stations occupied, with largest samples collected to the south and east of King George Island, and northwest of Elephant Island. Reproductively mature forms dominated the overall catch (79.1%) and constituted most of the individuals collected north of the islands; juveniles (14.7% of total) occurred primarily in the waters of Bransfield Strait. Most of the female krill exhibited ovarian development, but none appeared to have spawned. The overall size distribution reflected a prevalence of large, mature individuals (35-55 mm, median 47.5 mm), with a noticeable paucity of individuals in the 30-39 mm size class.

In conjunction with phytoplankton/primary productivity studies led by Osmund Holm-Hansen (Scripps Institution of Oceanography), observations were made of chlorophyll-a concentrations in surface waters throughout the 50-station sampling grid; the concentrations varied from 0.2 to over 2.0 mg per m^3. Highest phytoplankton biomass values were recorded in the area north-northwest of Elephant Island, and south-southwest of Clarence Island.

Anthony Amos (University of Texas at Austin) conducted physical oceanographic studies during the survey and identified a frontal boundary north of Elephant Island, possibly associated with the shelf break. This boundary separates the water of the Bellingshausen Sea to the west from that of the Weddell Sea to the east. Circumpolar Deep Water penetrated as far south as King George Island, but could not be found in Bransfield Strait. It was noted that most of the krill layers appeared to be confined to the upper mixed layer of the ocean.

On January 25, Rennie Holt was picked up from Seal Island and transferred to the Japanese research vessel *Kaiyo Maru* the following day, where he participated in the research activities of the Japanese Antarctic Research program through February 15.

In preparation for directed krill sampling using a MOCNESS net, two acoustic reconnaissance surveys were conducted in early February: one in areas of higher krill densities along the shelf break north of Elephant Island, and the other targeting a smaller area near Seal Island. Following the acoustic surveys, a total of 8 MOCNESS tows were conducted to sample krill and salps, each sampling 9 discreet layers ranging from the surface to 200 m. The data will be analyzed to determine correlations between acoustic target strength and krill concentrations from the MOCNESS.

Following the directed sampling operations, another survey was conducted north of Elephant Island to further study oceanographic conditions, phytoplankton biomass, and krill distribution and reproductive status. Higher krill densities were again encountered along the shelf break during this survey. Over 2,100 krill were collected in the 13 Isaacs-Kidd midwater trawl hauls made. Large, reproductively mature individuals dominated (90% of total) the samples, although one sample taken inshore of the shelf break contained mostly juvenile and immature stages. Mature males outnumbered females by 60%, and the sexes appeared to have different distributions: males occurred in greater proportion (65-97% of total) in the western offshore area, while females were relatively abundant (62-92%) in offshore and shelf areas to the north of the island. Nearly half of the females exhibited advanced ovarian development, although none was in post-spawning condition.

The discovery that the major concentrations of krill were located over the shelf break north of Elephant Island prompted a detailed investigation of the hydrography of this region. Two lines of closely-spaced CTD stations were made across the break where the shallow bottom of the continental shelf abruptly changes to the steep continental slope. A sharp frontal boundary was identified at the shelf break, where low salinity water typical of the Bellingshausen Sea abutted the more saline water of the Weddell Sea and/or Bransfield Strait. It was proposed that such a dynamic water mass boundary may well account for the observed krill distribution.

During the mid-cruise return transit across the Drake Passage, scientists aboard the *Surveyor* conducted six CTD casts to 2,000 m depths in support of scientists at Chile's Servicio Hydrográfico y Oceanográfico de la Armada (SHOA). The Polar Front was well delineated, and the data will be used to calculate geostrophic flow across the Drake Passage. On February 11, the *Surveyor* began a 5-day port call in Punta Arenas, where fresh provisions and new scientific party members were taken aboard. The *Surveyor* departed Punta Arenas on February 16 to begin Leg II of the cruise. (J. Rosenberg, FTS 893-5600)

Krill Predators Studied by Seal Island Field Team

John Bengtson, Peter Boveng, Don Croll, Mike Goebel, and John Jansen (all of the National Marine Mammal Laboratory) arrived at Seal Island on December 4, 1990, to conduct foraging and reproductive behavior studies on krill predators (penguins and seals) during the austral summer. Immediately after setting up camp, the scientists began observations of penguin nests and deployed the first time-depth recorders (TDRs) on chinstrap penguins. Because the scientists arrived early in the penguins' reproductive season, they were able to observe the incubation phase for the first time.

The fur seal pupping period was also in its early stages when the team arrived in early December; the scientists estimated that only 25% of the total number of pups expected had already been born. Towards the middle of December the team had deployed radio transmitters on 40 adult female fur seals, as well as attaching TDRs to about half of these animals. The team was pleased to find that some of these females were perinatal and had not yet left for their first feeding trips to sea.

Japanese scientist Yoshihisa Mori, part of the Japanese Antarctic Research program aboard the *Kaiyo Maru*, arrived at Seal Island in late December to begin a 30-day study of penguin foraging ecology and reproductive behavior. His visit was part of a Japanese/U.S. cooperative research program, which allowed U.S. scientists to participate in tracking studies of foraging penguins and fur seals aboard the *Kaiyo Maru*.

Also in late December, penguin eggs began hatching, and it was noted that there were approximately 20% fewer penguin nests this year compared to the 1989/90 season. The pupping season ended in late December, with a total of 285 pups born. The team observed a female fur seal, tagged at Seal Island as a pup in December 1986, returning to the island as an adult to give birth to a pup. In the last days of December, the field team began collecting and analyzing fur seal scat samples in conjunction with diet studies.

Two studies were initiated to evaluate the potential within- and between-season effects of attaching instruments to chinstrap penguins. Visual observations were made to compare attendance patterns at nests by birds with no instruments, radio transmitters, or TDRs. Dummy transmitters were deployed for different durations on two experimental groups to allow for a comparison of rates of return next year.

Bengtson, Boveng, and Jansen boarded the *Kaiyo Maru* on January 1, 1991 to begin tracking studies of penguins and fur seals. The studies were very successful, with 6 chinstrap penguins, 1 macaroni penguin, and 1 fur seal tracked during feeding trips away from Seal Island. The tracked fur seal was recorded to have traveled 140 nautical miles from the island in 2.5 days, which was more than twice as far as any fur seal followed in previous years. The seal's TDR was successfully recovered when she returned to the island. Preliminary analyses of fur seal attendance patterns ashore indicated that lactating females made substantially longer trips to sea this year (e.g. 6-9 days) than in previous years (e.g. 4-5 days). In mid-January, the scientists began weighing seal pups and penguin chicks to determine growth rates.

After completing his research project, Mori Yoshihisa returned to the *Kaiyo Maru* on January 19. He reported that his research on the island went very well, and that he was able to accomplish most of his research goals. Overall, the Japanese/U.S. cooperative research program was very successful, both in terms of tracking studies aboard the *Kaiyo Maru*, and of Yoshihisa's work on the island.

Macaroni penguin chicks began creching in late January, and the chinstrap penguin chicks soon followed. Nearly all cape petrel chicks hatched around late January as well. Increasing numbers of juvenile fur seals and penguins came ashore in the last days of January, many of which were known-age individuals that had been tagged or banded in previous seasons.

An annual fur seal pup census was conducted at Large Leap Island, located 1 km northwest of Seal Island. A total of 231 pups was counted, which was slightly lower than last year's count. The seal rookery on Large Leap Island is comparable in size to the one on Seal Island, and thus provides a useful comparison of an undisturbed site.

In late January, the scientists completed repairs to a National Weather Service automatic weather station on Seal Island. They replaced a damaged aluminum antenna with a new 20-foot tower made of steel. Sensors for wind speed, wind direction, relative humidity, temperature, solar radiance, and barometric pressure were installed at the station, as well as a refurbished data processing unit and transmitter, a new geostationary operational environmental satellite (GOES) antenna, and a solar panel.

The scientists began tagging fur seal pups in early February when the pups were molting into juvenile pelage. They observed chinstrap penguin chicks beginning to molt their down and show their juvenile plumage, and they noted the arrival ashore of nonbreeding birds for their annual molt. During tagging, it was observed that this year's rate of fur seal pup mortality was lower than that recorded at the same time last year. The scientists noted that predation of the pups by leopard seals was also reduced, compared to last year, and they postulated that this might account for the reduced mortality. The team also began banding chinstrap and macaroni penguins, and cape petrel chicks.

High seas on February 4 washed over study colonies on the north coast of the island. In one cove, the surf extended over the entire area of the fur seal rookery and three quarters of the chinstrap colony. Although most nests were destroyed, many of the chicks were old enough to survive. Most of the fur seal pups survived as well.

In preparation for a cooperative Chilean/U.S. research effort aboard the R/V *Alcazar*, the scientists deployed additional TDRs and radio transmitters on female fur seals in early February. On February 13, Bengtson and Boveng boarded the *Alcazar* at Seal Island to conduct studies of fur seal foraging behavior with simultaneous hydroacoustic and net sampling of zooplankton. The 10-day study was very successful, obtaining eight tracks of foraging female fur seals. Foraging ranges in February were much closer to Seal Island than during January, with the tracked females feeding about 20 nautical miles of the island. A portable hydroacoustic system that was mounted onto the *Alcazar* to assess zooplankton distribution worked fairly well, despite some technical difficulties.

In late February, the scientists recovered many TDRs from female fur seals and chinstrap penguins, and found the records produced by the instruments to be in good shape. The banding of penguins and petrels was also completed with a total of 2,000 chinstrap, 78 macaroni, and 37 cape petrel chicks banded on the island. In addition, studies of chinstrap chick growth and diet were completed.

At the end of February, the field team began preparing for their mid-March departure from Seal Island. The actual date that the *Surveyor* collects the team is dependent on weather and sea conditions. (J. Rosenberg, FTS 893-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Division Staff Prepares Proposals

John Hunter, Sue Williams (SDSU), and Larry Jacobson submitted a one-page proposal to the Coastal Ocean Program for California halibut research entitled "Habitat and productivity of California halibut–a case study for Southern California." The three scientists propose to determine the importance of shallow water bay habitats as a source of new recruits, and the relative value of different types of bay habitat for production of juvenile halibut. The research would build on the work done by Sharon Kramer while employed by the SWFSC.

Under the Coastal Ocean Program, Russ Vetter and John Hunter submitted two one-pagers: "Trends in toxic contamination: a time series analysis of the ongoing 40 year CalCOFI ichthyoplankton collections," and "Hydrogen sulfide toxicity and the survival of juvenile halibut in estuaries."

Working with Ray Smith (UCSB), Hunter and Vetter are also submitting a proposal to the NOAA Climate and Global Change Program. That proposal addresses biological effects of increased UV radiation on larval fish mortality. John Hunter, Paul Smith, Geoff Moser, Larry Jacobson, Russ Vetter, and N. Chyan-huei Lo, in cooperation with Michael Mullin and Andrew Soutar, are submitting a proposal addressing the use of scales in sediments to determine effects of long term climate change on the dynamics of key coastal pelagic fish stocks. Hunter is also preparing a proposal with David Mackas (Institute of Ocean Sciences, B.C.) for a west coast workshop for NSF GLOBEC (Global Ecology) to be submitted to NOAA's Climate Program. (J. Hunter, FTS 893-7127)

COASTAL EASTERN PACIFIC POPULATION BIOLOGY OF FISHES

Two New Researchers Join Physiology Team

Russ Vetter reports that David Caterino has joined the laboratory as a co-op student through San Diego State University. Caterino will be studying the capacity temperature adaptation and the effects of temperature on metabolism in Dover sole, California halibut, shortspine thornyhead, and California scorpionfish, for completion of his master's thesis.

The laboratory has extended an invitation to Dr. Ya Qu Chen, Chief of the Environmental Research Division, East China Sea Fisheries Research Institute, to work as a visiting scientist in the Physiology-Genetics group. Chen's tentative arrival date is May 1991. (R. Vetter, FTS 893-7125)

SURVEY SYSTEMS DEVELOPMENT AND EVALUATION

NSF GLOBEC (Global Ecology) Grant

Paul Smith reports that in February he began working on a joint NSF-Globec project with Professor Marc Mangel of UC Davis. They met on February 19 to begin work on theoretical models of interactions among small schooling fishes, their predator aggregations, and their food patches.

Smith and Mangel have also begun to assemble data on the scale and intensity of patterns of plankton, planktivores, and piscivores. Among the piscivores chosen were: the ondontocetes, like the common dolphin (*Delphinus delphis*); large fishes, like the temperate and tropical tunas; marine birds; and squid. The principal plankton group chosen was the copepods.

The project's goal is to explore effects of distributional pattern on the interactions of schooling fishes with their principal prey and predators. The process begins with the physical oceanography of the coastal reaches of the California Current Region. It then proceeds through the scale and intensity of zooplankton patches to the growth rates and survival of the juvenile stage of the populations of schooling fish. Dynamic modelling will be among the approaches used for evaluating the effects of climatic change on the productivity of the schooling coastal fish populations. (P. Smith, FTS 893-7169)

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Wetfish Economics

Cynthia Thomson and Larry Jacobson visited the Fisherman's Cooperative in San Pedro, California, to meet with Tom Crehn (General Manager) and wetfish fishermen to obtain information about fish-

ing costs in the wetfish fleet. Jacobson also met with John Royal (Fisherman and Allied Worker's Union) who provided him with a complete set of "settlement sheets" for 1990. Settlement sheets are used by the union and boat owners to calculate crew shares and contain complete records of operating expenses (fuel, ship-to-shore radio usage, food, spotter plane costs, etc.) for individual trips by boats with union crews. The data are being used to refine a "break-even exvessel cost" model for the anchovy reduction fishery. The model, which was developed in the course of amending the anchovy FMP, is designed to estimate the minimum exvessel price for profitable fishing and will help managers evaluate the potential for resurgence of the anchovy reduction fishery. It is likely that the model will also be useful in connection with other species taken by the wetfish fleet (e.g. Pacific sardine).

Doyle Hanan (CDF&G) and Pablo Arenas (IATTC) provided Thomson and Jacobson with logbook data for seven vessels operating in the wetfish fleet during 1966-1979. The logbook data, which were used in preparation of Amendment 5 to the anchovy FMP during 1983, will be used by Thomson and Jacobson to estimate the duration of fishing trips, number of trips per year, and operating costs for the wetfish fleet. (L. Jacobson, FTS 893-7117)

California's Living Marine Resources

Larry Jacobson completed a chapter describing the northern anchovy fishery for the new "California's Living Marine Resources and Their Utilization." (L. Jacobson, FTS 893-7117)

Paper on Outlier Analysis Presented at Economics Conference

Industry Economist Cynthia Thomson presented a paper at a conference in Monterey, California, sponsored jointly by the Western Regional Science Association and the Western Regional Project on Benefits and Costs in Natural Resource Planning. The paper, entitled "Detecting outliers and influential observations in contingent valuation surveys," describes procedures for identifying outliers and influential observations in the context of a general linear model. "Case" statistics that can be used to identify single outliers in a sample are discussed as well as a number of rejection rules that can be used to evaluate whether the outlier is an unusual observation that is nevertheless consistent with natural variability of the population, or a contaminant that comes from a different population.

Multiple outliers can be identified by two types of procedures: consecutive and block. A consecutive procedure involves repeated application of a single-outlier case statistic to a progressively smaller sample. The case statistic is first computed for the entire sample and a rejection rule applied to the observation associated with the most extreme value for the statistic. If the rule indicates that the observation is a contaminant, it is deleted from the sample, a new version of the case statistic is computed for the remaining $n-1$ observations, and the rejection rule is applied a second time. These steps are repeated until the rule indicates that there are no more contaminants in the sample. In situations where multiple outliers are clustered near each other, however, a consecutive procedure may cause an extreme observation to be masked by its neighbors. Masking is responsible for a significant reduction in power when consecutive procedures are used to identify multiple outliers.

The alternative is to use a block procedure which involves the simultaneous testing of a subset of the sample for the presence of outliers. This procedure involves computing a block statistic for a subset of k observations and applying a rejection rule to determine whether the subset, as a whole, contaminates the sample. If the k-subset is not found to be a contaminant, the block statistic is computed for each combination of $k-1$ observations in the k-subset and the rejection rule is applied to the $k-1$ subset associated with the largest value of the block statistic. The process is repeated on successively smaller subsets until the rule identifies a subset of contaminants. Thomson's paper describes several block statistics, as well as techniques for choosing a k-subset with which to initiate a block procedure. In general, block procedures reduce the possibility of masking, provided that k is chosen sufficiently large. If k is too large, however, block procedures may cause observations that are not contaminants to be "swamped" by those that are.

Of particular interest are outliers that are influential; that is, they affect inferences about the population. In addition to case statistics for detecting outliers, the paper describes case statistics that measure the effect of individual observations on parameter estimates and predicted values.

The paper concludes with several comments and recommendations:

1. Although the procedures discussed in the paper necessarily involve subjective judgment, they

are preferable to the *ad hoc* procedures commonly employed. This is because the statistics and rejection rules allow for subjective judgement in an explicit and consistent manner and encourage more careful consideration of the data than might otherwise occur.

2. The contaminants may be legitimate observations that provide insight into the behavior of "unusual" individuals or the response of "ordinary" individuals to unusual events. Therefore, it is appropriate to set aside observations that are found to be contaminants, but it is not necessarily appropriate to throw them away.

3. More description in published analyses regarding identification and treatment of outliers and influential observations is recommended because the information is helpful for evaluating validity of conclusions and their sensitivity to the presence or absence of unusual observations.

The paper will be published as part of the conference proceedings. Thomson is working on a follow-up paper in which procedures for identifying outliers and influential observations are applied to an economic data set. (C. Thomson, FTS 893-7116)

Southwest Region Economists Meet

Economists from the Southwest Fisheries Science Center and the Southwest Region (SWFSC/SWR) held their annual mid-year meeting January 17-18, 1991 in La Jolla, California, to review progress on economic research projects conducted under the SWFSC/SWR Socioeconomic Research Fund (SRF). The SRF originated with the implementation of the Magnuson Fisheries Conservation and Management Act (MFCMA) and was established to augment research capacity of NMFS economists at the regional level. The fund provides for high priority research programs in economics that support fisheries management under the MFCMA. The socioeconomic research fund is administered by the Commercial and Recreational Fisheries Research for Management Program in the Coastal Division of the SWFSC, La Jolla.

Current efforts deal primarily with the west coast groundfish fishery, recreational fishing in southern California and development of fishery management plans for the western Pacific. SRF projects for FY-1991 and progress to date are as follows:

1. Survey of published work on marine habitat damage assessment and the assessment of impacts from a critical habitat declaration:

The purpose of this work is to compile information that can be used to write and evaluate contracts administered by SWR. The work will be done by a graduate student whose dissertation involves economic valuation of habitat. The product of this work will be an annotated bibliography. At least one suitable graduate student candidate has been identified.

2. Support for long-term research on recreational fisheries:

The purpose of this work is to obtain and analyze economic, demographic and fishing effort data from west coast recreational fisheries. The data are used by managers to evaluate options for allocating catches to commercial and recreational fisheries and in writing fishery management plans.

Data collected during the recently completed Southern California Recreational Angler Survey are being analyzed. The product of this work will include a data report and scientific papers. A preliminary version of the data report is already available.

Preparations for a cooperative recreational fisheries survey with the Mexican Department of Fisheries are progressing nicely. Questionnaires have been developed to obtain socioeconomic and demographic data from Americans fishing in Mexican waters. The product of this work will be information about the value of American participation in Mexican fisheries and information about fishing effort.

3. Economic value of Hawaii's recreational billfish fisheries:

The purpose of this work is to determine the value of recreationally-caught billfish in Hawaii so that options for allocating catches to the recreational, longliner and troll fisheries can be evaluated. A survey has been completed and data are being analyzed. The product of this research will be data used by the Western Pacific Fishery Management Council.

4. Survey to determine the costs of trawling for groundfish:

The purpose of this work is to obtain information needed to evaluate limited entry options for the west coast groundfish fishery and to upgrade

economic models for Pacific coast sablefish and groundfish fisheries. A request for proposals has been issued.

5. Support for long-term research on commercial fisheries:

The purpose of this research is to develop a more realistic economic model for the groundfish fishery. Work on a positive quadratic programming model for the Pacific coast groundfish fishery is ongoing. To date, an abbreviated version of the model has been developed and calibrated. Additional information about prices is being developed for use in the model. This research will eventually produce a better model for analysis of management options.

The Center's West Coast Fishing Fleet Cost-Earnings Data Base will be updated this year to obtain detailed financial data from fishing vessels that participated in NMFS's financial assistance programs during recent years. These data are used routinely by SWR economists.

Arrangements have been completed for Jon Conrad (Department of Resource Economics, Cornell) to begin developing a bioeconomic model of the California wetfish fishery as a summer faculty fellow during 1991. The purpose of this work is to determine optimal levels of fishing effort in the wetfish fishery, and will result in a report describing the feasibility of developing a suitable model.

6. Economic impact of farmed salmon imports on the west coast commercial ocean troll salmon fisheries:

This work will determine how imports of cultured salmon affect the fisheries and markets for commercially caught fish. An approach to determining these effects has been identified, and a qualified scientist is being sought to work as a summer faculty fellow during 1991.

Additional information on the SRF and the research it supports is available from the Commercial and Recreational Fisheries Research for Management Program, Coastal Fisheries Resources Division, Southwest Fisheries Science Center. (S. Herrick, FTS 893-7111)

ITQ Economics Research

Industry Economist Dale Squires has completed a study on the potential effects of individual transferable quotas (ITQ) for thornyheads in the deepwater fishery for Dover sole, thornyheads, and sablefish in the Eureka INPFC area. The study uses production economics and econometric methods to assess the probable equilibrium market price, the potential gains in economic rent with management (based upon transferable property rights), and the probable industry structure after quotas have been exchanged. Junior Economist John Lanfersieck is completing a similar type of analysis using linear programming methods for a sample of sablefish longline vessels. Both studies are part of a long-term, systematic effort to develop the most appropriate methodology by which to analyze prospective individual transferable quota programs. These prototype studies will be followed by at least two more analyses that will extend the methodologies. (D. Squires, FTS 893-7113)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

Reorganization of the Marine Mammal Division

Prior to the recent reorganization of the Marine Mammal Division, it consisted of four programs: 1) the Biological Assessment Program, dealing with interpretation of life history patterns in eastern tropical Pacific (ETP) dolphins, dolphin stock identification and photogrammetric surveys of marine mammals; 2) the Dolphin Stock Assessment Program, concerned with research vessel surveys in the ETP and the analysis of data collected during those surveys; 3) the Coastal Marine Mammal Program, responsible for the monitoring and assessment of coastal marine mammal populations; and 4) the Fishery Dependent Assessment Program, dealing with tuna vessel observer data (TVOD) and ETP ecosystem research. The Fishery-Dependent Assessment Program has since been divided into two new programs: the Dolphin Ecology Program, led by Dr. Steve Reilly and the Fishery-Dependent Analysis Program, led by Dr. Elizabeth Edwards. This division will allow people outside of the Center to follow research activities and publications of specific research teams more easily. The other three programs remain unchanged; a summary of the new organization is shown in Figure 1. (D. DeMaster, FTS 893-7165)

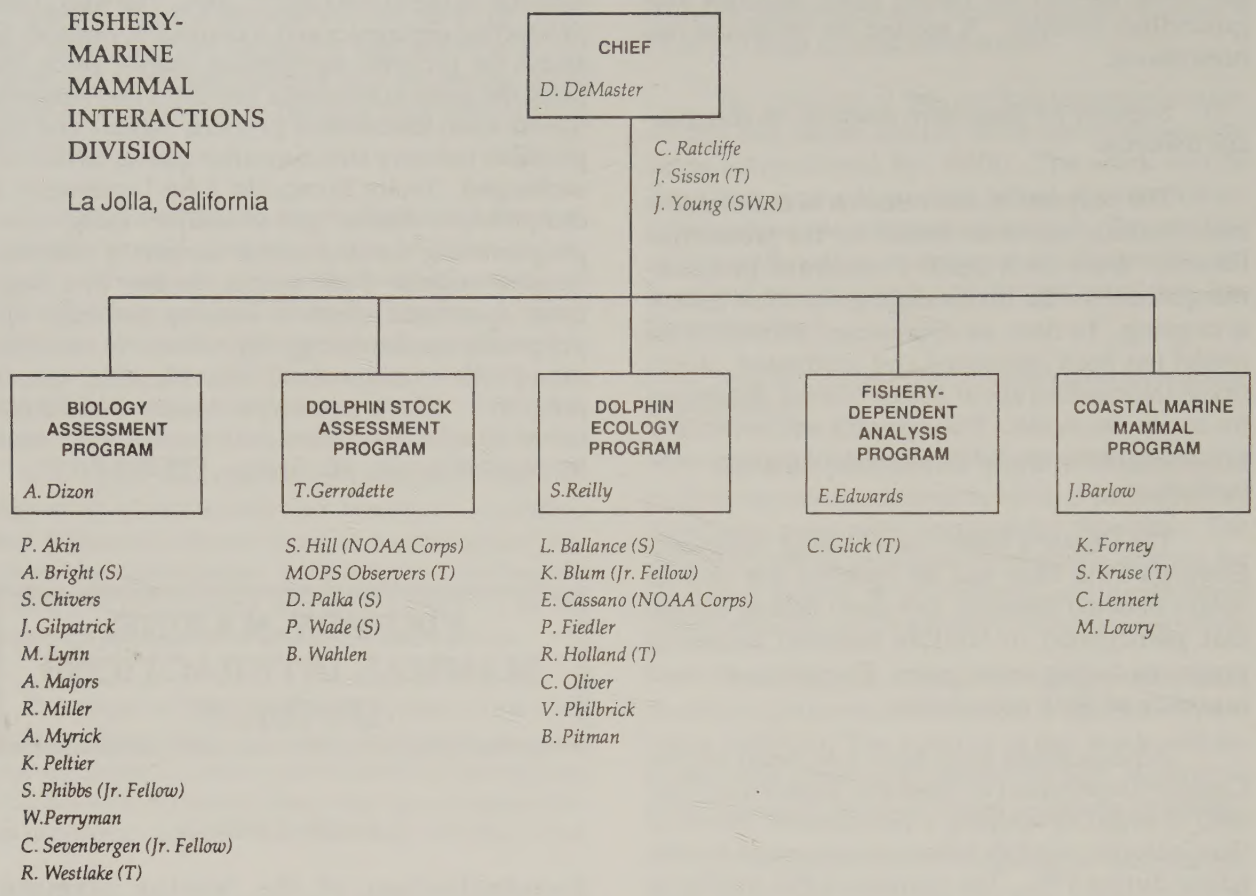

Figure 1. Fishery-Marine Mammal Interactions Division organization chart.

Marine Mammal Observers Return from Acoustic Global Warming Feasibility Experiment

On February 15, NMFS marine mammal observers aboard two Navy research vessels, the *Cory Chouest* and the *Amy Chouest*, completed the first in a series of surveys in conjunction with the Acoustic Global Warming Feasibility Experiment. The experiment was implemented by the Scripps Institution of Oceanography, the University of Washington, the University of Michigan, and the Commonwealth Science and Industrial Research Organization, Tasmania, Australia. Other participants included the Monterey Bay Aquarium Research Institute, the Woods Hole Oceanographic Institute, the State of California, and NOAA. The primary objective of the experiment was to determine the feasibility of using long range acoustic techniques to detect global warming over a 10 year monitoring period. According to existing atmospheric-ocean models, the ocean warming taking place in response to the release of "greenhouse" gasses should be detectable using appropriate experimental means.

Secondary objectives included: determining the minimum sound source that would provide reliable sound levels at various receiving stations; measuring the sound level at pre-determined depths and distances from the source; collecting information to estimate the density, size, and species composition of marine mammals in the vicinity of the acoustic source before and during the experiment; and determining the manner in which sound levels at various distances from the source affect marine mammal populations. A tertiary objective was to collect information to estimate the density, size, and species

composition of cetaceans while in transit to and from the study site, as well as to collect data that contribute to ongoing U.S. and international programs investigating oceanography in the southern Indian Ocean.

NMFS marine mammal observers Scott Benson, Robert Pitman, Richard Rowlett, and Debra Palka monitored marine mammal activity before, during, and after the experiment, using line transect and acoustic methods. The conditions for visual observations were less than perfect, with an average Beaufort sea state of 6, air and sea surface temperatures in the 3-4 ℃ range, and winds at an average of 28 knots with occasional gusts of up to 70 knots. Collecting data on marine mammals in these conditions proved difficult, but not impossible for the observers.

The observers were part of a team responsible for determining the distance at which the sound level attenuated to 160 dB at 80-100 m depth. Until the 160 dB isopleth could be established, a 5 km distance was considered the threshold at which larger whales would be in jeopardy from the source transmissions. The interest in sound levels at the 80-100 m depth was based on the assumption that this was the depth at which most of the phytoplankton and plankton would be found during daylight hours, corresponding to the feeding depth of many of the larger whales. However, an acoustic-backscattering device found the scattering layer at 40-80 m depths.

A daily watch for marine mammals was maintained during daylight hours. During evening transmissions, observers maintained visual watch for marine mammals with the aid of a Night Viewing Device scope. From the preliminary results, examples of marine mammals sighted include: hourglass dolphins, bottlenose whales, beaked whales, pilot whales, blue whales, fin whales, unidentified dolphins and whales, fur seals, and elephant seals. The bioacoustic set-up consisted of a hydrophone/sonobuoy-receiver system where sonobuoys were deployed as needed for continuous acoustic coverage. Hydrophone depth was set at 80 m. While on effort, the location, school size, and species composition of all marine mammals were noted, along with surfacing intervals and swimming direction and speed, when possible. In addition, sightings and behavior of seabirds (penguins in particular) were recorded opportunistically.

Behavioral, acoustical, and line transect data collected during the survey are currently being analyzed. The results of the research will be used to determine if this type of acoustic activity affects marine mammals and whether modifications of the acoustic research design would be needed to mitigate any adverse impacts. Workshops will be held at the SWFSC in August to discuss these results. (D. DeMaster, FTS 893-7165).

FISHERY-DEPENDENT ANALYSIS PROGRAM

New Program Responsible for Analyzing Tuna Vessel Observer Data, Skipper Performance, Mortality Comparability, and Alternative Gear Research

Fishery Biologist Elizabeth Edwards and Statistician Cheryl Glick have undertaken a number of tasks utilizing tuna vessel observer data (TVOD). The first of their tasks is to evaluate the statistical effects of small fleets on dolphin mortality rates. These results will contribute to estimating mortality comparability between U.S. and foreign fleets, and should prove interesting considering few U.S. vessels are fishing "on dolphins." Edwards and Glick are also responsible for analyzing skipper performance. This will be accomplished by summarizing dolphin-kill-per-set for U.S. skippers from 1984 through the present. At a minimum, this summary will include data collected by NMFS observers on U.S. vessels. Where possible, Inter-American Tropical Tuna Commission (IATTC) data for U.S. vessels will also be summarized. Edwards and Glick will also continue their work on TVOD trend analysis of dolphin abundance, including power analyses of estimated trends. They plan to refine the tuna vessel observer program simulator (TOPS) model which estimates dolphin abundance derived from simulated TVOD and research vessel observer data (RVOD), using realistic environmental topographies. Finally, the program will be offering statistical support to the Division's Biology Program in order to elucidate the basis of the tuna-dolphin bond, as well as to the Alternative Gear Program for the development of alternative fishing methods. (E. Edwards, FTS 893-7099)

BIOLOGY ASSESSMENT PROGRAM

Stock Definition Paper Submitted to the Journal of Conservation Biology

Biologists Andrew Dizon, Christina Lockyer, Bill Perrin, Doug DeMaster, and Joyce Sisson have reviewed various definitions of "stock" that could be used for management purposes to circumscribe a biological population. They have recently submitted the results of this work in the form of a review manuscript entitled, "Rethinking the stock concept: a phylogeographic approach," to the Jour-

nal of Conservation Biology. They are hopeful that the suggestions and examples discussed in the manuscript regarding how to classify stocks will aid resource managers in making informed decisions on how to set priorities for management.

The concept of "stocks" is central to two federal environmental Acts pertaining to marine mammal species. The Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973 both deal with the management of exploitable species. Although no useful working definitions of stock are provided in them, it appears that the intent is to direct management efforts to taxon levels below that of the species (evolutionary significant unit, ESU). This ensures that populations uniquely adapted to given areas are not irreversibly reduced by harvest or habitat destruction.

In practice, stock status has been conferred within species using a variety of proxies that imply reproductive isolation. With isolation comes genetic divergence through drift and local adaptations via such processes as differential selection or character displacement. Nevertheless, because reproductive barriers within species are fragile or incomplete, especially in the marine environment, the degree of isolation of one population relative to others can be complex, varying both in space and time. The authors show how population structure can be described in a way that captures this complexity.

Following the framework devised by J. C. Avise (Evolution 43(6):1192-1208), which organizes hypothetical population structures relating the two critical concepts of selection and movement, Dizon's group has made the model operational for management purposes. Avise's approach classifies assemblages into one of four categories based on two criteria: mtDNA genetic distance and spatial distribution. Dizon's group presents a modified version of these four phylogeographic classifications basic to Avise's approach. In Figure 2, the horizontal axis indicates the degree of differential selection likely to have occurred in one population relative to another. It represents differences in characters that are the expression of the local adapted genome, rather than simply the mtDNA genetic distance. Measures on this axis represent the culmination of selection that operates on many generations. The other axis of the matrix is gene flow and its proxy, distribution difference. This gene flow axis is considered separately to emphasize that available information is usually indicative only of potential gene flow; actual flow of genes requires the production of fit offspring.

Phylogeographic Types

Geographic Localization	great	III	I
	little or none	IV	II
		little	great
		Genetic Divergence	

Figure 2. Four phylogeographic classification categories. The genetic axis refers to the genes that make up the locally adapted genome. (After J. C. Avise. 1989. "Gene trees and organismal histories: a phylogenetic approach to population biology." Evolution 43(6):1192-1208.)

The advantage of looking at populations in this way is that a hierarchy of the four population relationships can be described operationally. It is a hierarchical relationship because, with each step, there is an increasing probability that the population in question is an ESU. It should be noted that in characterizing a single population for management purposes, it is always considered relative to another reference population.

The manner in which such a phylogeographic classification of any given population is made, and the confidence in such a decision depends on the amount of information available. Dizon and the scientists working with him suggest that the information available be appended to the phylogeographic taxa in a shorthand method (Figure 3). They contend that a shorthand notation is necessary because resource management documents usually contain extensive lists of stocks that are being considered for separate management status. Using this new approach, reference to a given management unit would carry with it infor-

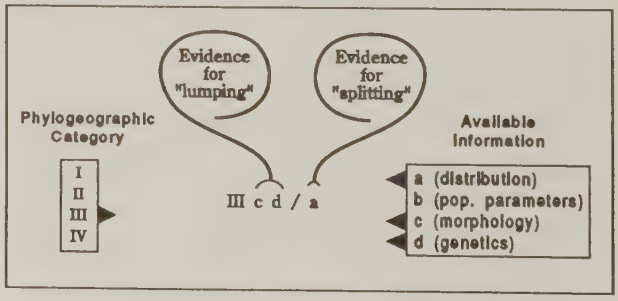

Figure 3. A shorthand method for qualifying stock type using phylogeographic categories and information regarding the criteria used to make such qualifications.

mation regarding its phylogeographic structure (category type) and the data from which that decision was made (criteria basis).

The phylogeographic category is designated by Roman numerals (I, II, III, or IV). The proxy information with which decisions regarding the population are made, is designated as: "a" (distribution and movement), "b" (population response), "c" (phenotypic differences), and "d" (genotypic differences). A population would be designated according to phylogeographic category and decision criteria (e.g., IIa/bcd). Letters to the left of the solidus would represent data for "lumping" the entire population into one stock, and those to the right, data for "splitting" the population into separate stocks (Figure 3).

To illustrate the procedure, Dizon's group chose the minke whale (*Balaenoptera acutorostrata*) because it represents a species that has been comparatively well investigated and defined in terms of stock identity. This species contains populations demonstrating each of the four phylogeographic categories. Within the manuscript, the current biological information on the species is described in detail, covering as much ground as possible under each of the four criteria. Classifications are then suggested for the various putative stocks.

This proposed system of classification addresses only single-species considerations. Keeping in mind other ecological phenomena, such as predator-prey interactions, the existence of keystone species and species guilds (etc.), a population may have importance beyond its qualifications, or lack thereof, as an ESU; these factors must also be considered in deciding what should comprise a management unit. Future exercises using this classification method are planned for other marine mammals managed under the Marine Mammal Protection Act and the Endangered Species Act. (A. Dizon, FTS 893-7089)

DOLPHIN ECOLOGY PROGRAM

Primary Productivity of the Eastern Tropical Pacific Ocean

As a part of the Monitoring of Porpoise Stocks Program, the Dolphin Ecology Program has been collecting oceanographic data annually in the eastern tropical Pacific (ETP), from August to November, since 1986. These data are used to quantify spatial and interannual habitat variability in studies of dolphin distribution and trends in abundance. In 1990, Oceanographers Paul Fiedler and Valerie Philbrick added ^{14}C-uptake to the routine suite of measurements, including temperature, salinity, chlorophyll, nutrients, and dissolved oxygen. Collaborator Francisco Chávez of the Monterey Bay Aquarium Research Institute handled nutrient analyses and provided advice and equipment for the productivity measurements. On the NOAA Ships *David Starr Jordan* and *McArthur*, 172 productivity stations were completed. Such extensive sampling of primary productivity has not been carried out in the ETP since EASTROPAC in 1967-1968.

The most productive site in the oceanic tropical Pacific is the equatorial upwelling zone. A strong divergence of the South Equatorial Current, driven by the southeast trade winds, brings cool, nutrient-rich water into the surface layer and causes a ridging of the underlying thermocline. A weaker divergence occurs along 10°N, between the North Equatorial Countercurrent and the North Equatorial Current. The Costa Rica Dome is at the eastern end of the thermocline ridge beneath this countercurrent divergence. Surface waters here remain warm and stratified, except during winter at the Costa Rica Dome, where rates of divergence and upwelling are comparable to equatorial rates. Nitrate results from 1986 to 1988 samples show that equatorial surface waters are nutrient-rich (4 µg-at N l^{-1}, Figure 4). While surface waters over the countercurrent thermocline ridge are nutrient-depleted (µg-at N l^{-1}), even at the Costa Rica Dome, nutrient-rich subsurface waters are found within the euphotic zone from the dome out to 105°W (not shown).

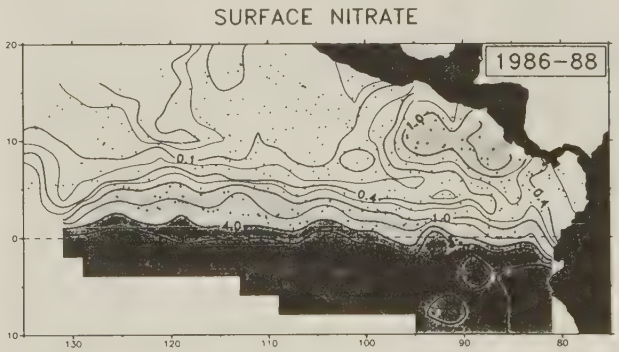

Figure 4. Surface nitrate concentrations (µg-at N l^{-1}), 1986-1988.

In 1990, surface chlorophyll was high along both the equatorial and countercurrent divergences east

of 105°W (Figure 5). The highest values were at the Costa Rica Dome, around the Galapagos Islands, and off the coast of Ecuador. Primary productivity was high along the countercurrent divergence, from the Costa Rica Dome to 105°W, and along the equatorial divergence, from the coast of Ecuador to 110°W. Productivity was low along the countercurrent divergence west of 105°W, where euphotic zone waters are nutrient-depleted due to weak upwelling and vertical mixing.

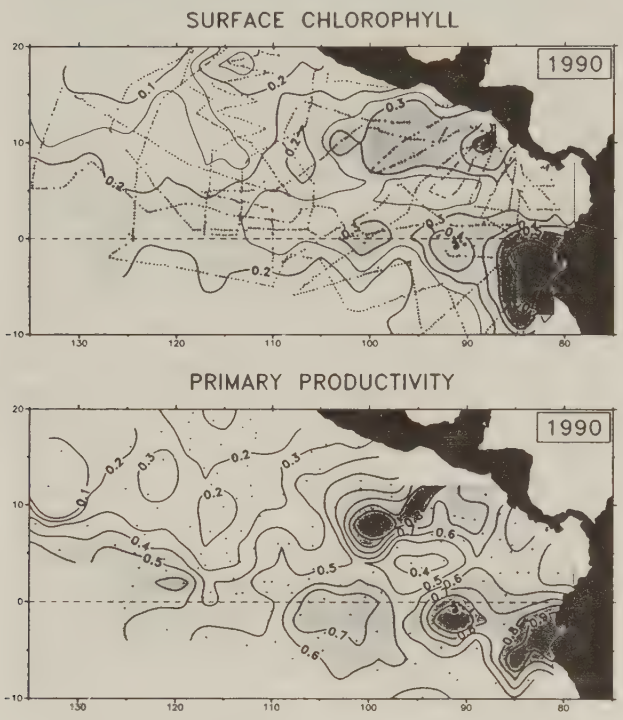

Figure 5. Surface chlorophyll (mg m^{-3}) and integrated primary productivity (gC m^{-3} day^{-1}), 1990.

These results show that in the eastern tropical Pacific, primary productivity is high along two divergences where upwelling maintains high nutrient concentrations in the euphotic zone. Productivity decreases towards the west, as the nutricline deepens and nitrate concentration decreases both at the surface and throughout the euphotic zone. This implies nutrient limitation, but nitrate is never depleted in equatorial waters. The equatorial Pacific (including the Costa Rica Dome), subarctic Pacific, and Southern Ocean are classified as high nutrient/low chlorophyll (HNLC) waters. These results were presented at an American Society of Limnology and Oceanography Symposium that took place in San Marcos, California, from February 22 to 24, in a report entitled "What controls phytoplankton reduction in nutrient-rich areas of the open sea?" The symposium was convened to examine the hypothesis that iron, rather than light or grazing, limits productivity in HNLC situations. (P. Fiedler, FTS 893-7016).

COASTAL MARINE MAMMAL PROGRAM

California Coastal Cetacean Surveys Initiated

The recently established gillnet observer program has started generating information on marine mammal mortality in coastal fisheries. However, it will not be possible to judge the impact of this mortality without abundance estimates for the marine mammal species which are caught. It is likely that future management of cetaceans will be based on a percentage quota applied to the minimum abundance estimate (a minimum count; or the lower 95th percentile of a statistically based population estimate). Currently, abundance estimates are available for some of the more common species in California coastal waters, but the estimates are over 10 years old, and statistical confidence limits are only available for one species.

The Southwest Fisheries Science Center's Coastal Marine Mammal Program will conduct aerial surveys between March 11 and April 11, 1991, to obtain minimum populations estimates for cetaceans along the California coast. The aerial observer team consists of Program Leader Jay Barlow, and five marine mammal observers: Karin Forney, Sue Kruse, Carrie LeDuc, Rick LeDuc, and James Carretta. According to climatic atlases of the California coast, March and April have been chosen for the survey since these months have, on average, the coldest sea surface temperatures. Additional ship or aerial surveys are planned for the fall of 1991 during warm water conditions so that both temperature extremes can be covered. Standard line transect methods will be used, and minimum population sizes will be estimated as the lower 95th percentile, based on empirical variance estimators.

The primary objective of the surveys is to obtain minimum winter population estimates for the common cetacean species in California waters. The secondary objective is to establish a baseline for detecting changes in marine mammal abundance through time (seasonally and interannually). The final objective is to add to the body of information on the distribution and seasonal movement of cetaceans along the coast of California.

The survey area extends beyond the continental shelf edge along the California coast, to roughly the 3000-4000 m depth isobath. The area was selected to encompass all of the known driftnet fishing area, based on effort data for California Department of Fish and Game blocks. In Central/Northern California (CNC), this extends from the coast to approximately 100 nautical miles of perpendicular distance offshore. In the Southern California Bight (SCB), the study area is bounded by the U.S./Mexican border in the south, out to approximately 150 nautical miles offshore (the edge of the CDF&G blocks). It then follows a straight line northwestward to a point 100 nautical miles off Point Conception, connecting with the CNC area (Figure 6).

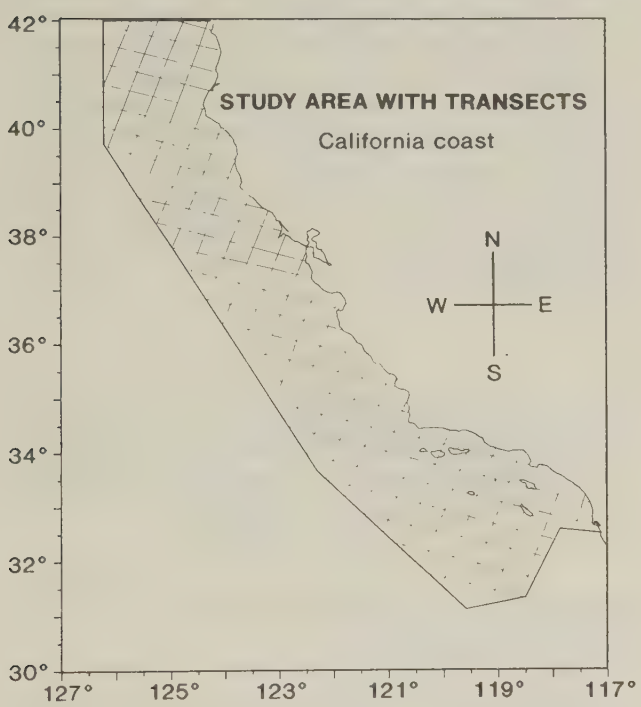

Figure 6. California coast study area with transects.

The species/species group for which minimum abundance estimates are expected to be obtained include:

Balaenoptera physalus	Fin whale
Balaenoptera acutorostrata	Minke whale
Delphinus delphis	Common dolphin
Globicephala macrorhynchus	Short-finned pilot whale
Grampus griseus	Risso's dolphin
Lagenorhynchus obliquidens	Pacific white-sided dolphin
Lissodelphis borealis	Northern right whale dolphin
Phocoenoides dalli	Dall's porpoise
Physeter macrocephalus	Sperm whale
Tursiops truncatus	Bottlenose dolphin (offshore)
All Ziphiid whales	Beaked whales

Additional species may be sighted, but will probably have insufficient sample sizes for abundance estimations. All cetacea and turtles sighted will be recorded.

A total of 76 transects form an approximately uniform grid with lines spaced 45-50 nautical miles apart (Figure 6). The location of the grid was chosen without reference to specific areas or topographical features. The transects will be replicated 2-3 times, as weather permits. Precision estimates in terms of coefficients of variation of the abundance estimate for the three survey scenarios are shown in Table 1. These estimates of precision, which are based on rsults of past surveys, represent a best approximation of what may be obtained in these aerial surveys. A full pass of the 76 transects would take approximately eight survey days. However, the actual number of days required will undoubtedly be

Table 1. Estimates of precision in terms of the coefficient of variation of the abundance estimate for three different levels of survey effort. A pass is defined as the completion of an entire grid.

SPECIES	COEFFICIENT OF VARIATION		
	2 complete passes	3 complete passes	2 complete passes + one pass in the SCB
Common dolphin	0.355	0.274	0.328
Bottlenose dolphin	0.805	0.549	0.562
Risso's dolphin	0.373	0.300	0.332
Pacific white-sided dolphin	0.480	0.407	0.459
Northern right whale dolphin	0.931	0.746	0.769
Pilot whale	0.730	0.642	0.714
Dall's porpoise	0.505	0.358	0.485
Beaked whales (as a group)	0.488	0.383	0.447

higher, due to poor weather conditions. The transects will be replicated twice. A third set of replicates in the CNC area would only be possible under exceptionally good weather conditions throughout the survey period. (J. Barlow, FTS 893-7178)

ALTERNATIVE GEAR PROGRAM

NMFS Program Investigates Alternative Fishing Methods

The Southwest Region of the National Marine Fisheries Service has established the Eastern Tropical Pacific (ETP) Gear Program, aimed at developing alternative (tuna-fishing) methods that will reduce or eliminate the incidental mortality of dolphins. The program, headed by Fishery Biologist John Young, was established in the summer of 1990, and is located at the Southwest Fisheries Science Center (SWFSC) in La Jolla, California, within the Fishery-Marine Mammal Interactions Division. Young's current efforts include collaboration with the tuna industry, the Inter-American Tropical Tuna Commission (IATTC), the environmental community, the Marine Mammal Commission, the National Academy of Sciences, and staff of the SWFSC. The purpose of this collaboration will be to develop refinements to existing gear and fishing methods, or to develop new gear and techniques that will help maintain the ETP tuna purse seine fishery while reducing or eliminating dolphin mortality.

The ETP Gear Program is directed toward developing alternative methods of searching for, aggregating, and catching tuna that are not in association with dolphins, and separating tuna and dolphins prior to fishing operations.

Projects that have been initiated to date include the awarding of a contract to a private firm for the development of an airborne optical laser system designed to increase the searching efficiency for surface and sub-surface fish. Testing aboard a helicopter in the local waters off San Diego, and subsequently in the ETP aboard a U.S. tuna purse seine vessel, is planned in early spring.

A second project to investigate the effectiveness of drifting fish aggregating devices (FADs) in the ETP began in the fall of 1990. FADs of various designs have been fielded aboard purse seine vessels for short term use, and two FADs equipped with satellite transmitters for long term tracking have also been deployed. Some success in catching tuna associated with these FADs has been experienced, although yellowfin catches have generally been of small fish, under 15 pounds. These early FAD experiments are considered preliminary to a larger project set to begin in the spring of 1991, in which 60 or more FADs will be deployed in areas where larger yellowfin and bigeye tuna are to be expected, and natural flotsam is scarce. This project, funded by Bumble Bee Seafoods, will involve the staff of the IATTC, the SWFSC, and vessels of the international tuna purse seine fleet, and will utilize FADs of various designs equipped with satellite transmitters and medium frequency radio beacons. Vessels will have substantial opportunity to supplement their normal searching efforts with visits to these drifting "logs."

A third project will involve attempts to break the bond between tuna and dolphins prior to fishing operations. The owner of the tuna seiner *Hornet III* has proposed devoting ship time aboard his vessel for this purpose. The funding for equipment and materials other than ship time is being provided by the United States Tuna Foundation. On this cruise the first attempts at separating tuna and dolphins prior to net release will be conducted. The goal is to catch tuna that associate with dolphins without encircling the mammals with the purse seine. The vessel is due to depart in late March. (J. Young, FTS 893-7148)

HONOLULU LABORATORY

Honolulu, Hawaii

INSULAR RESOURCES INVESTIGATION

Annual Status of Lobster Stocks Is Completed

February 1991 marked the completion of the sixth annual assessment of two lobster stocks in the Northwestern Hawaiian Islands (NWHI): the spiny lobster (*Panulirus marginatus*) and the slipper lobster (*Scyllarides squammosus*). Based on data from both commercial logbooks and research sampling, fishing effort by the NWHI lobster fishery in 1990 totaled almost 1.2 million trap-hauls, resulting in landings of about 591,000 spiny lobster and 184,000 slipper lobster, and a catch per unit effort (CPUE) of 0.66 lobster/trap-haul (Figure 1). This is the lowest annual CPUE since the inception of the fishery in the late 1970s.

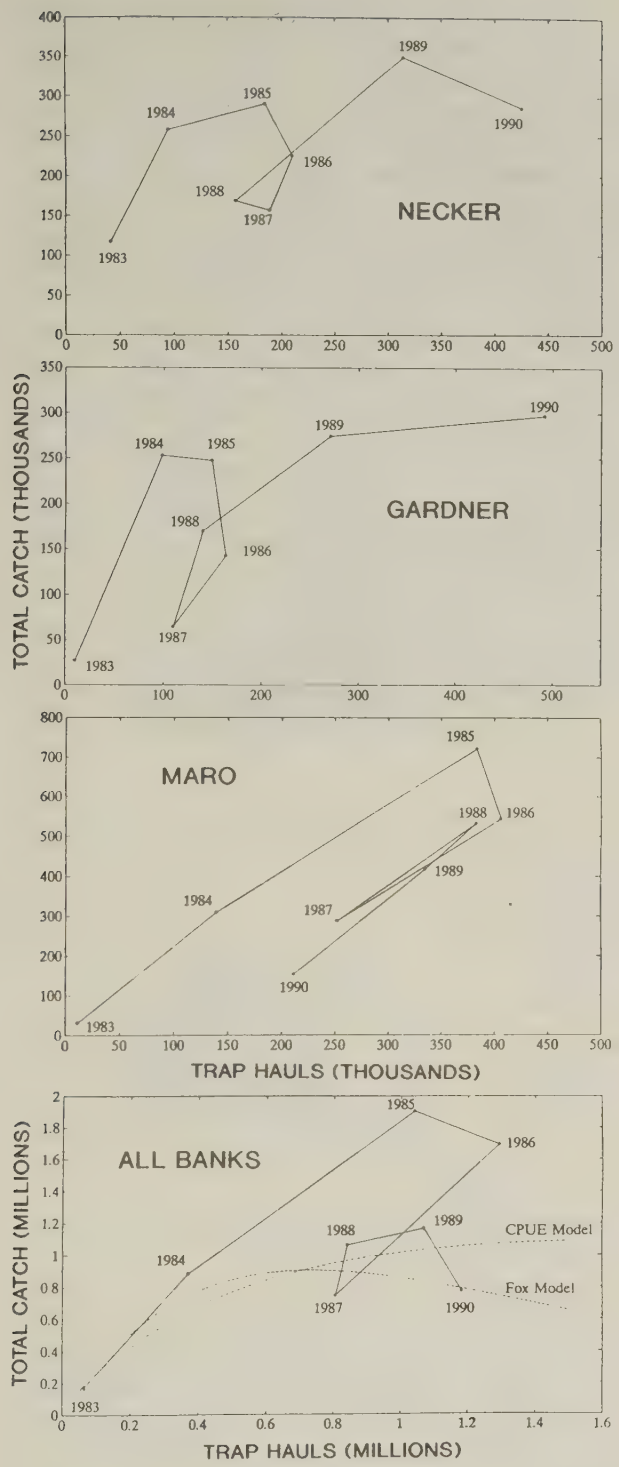

Figure 1. Catch and effort for spiny and slipper lobsters from commercial logbooks for Necker Island, Gardner Pinnacles, Maro Reef, and all of the Northwestern Hawaiian banks combined, 1983-90. Equilibrium catch and effort curves for the Fox production model and CPUE model are shown with the catch and effort for all banks.

From the analyses of commercial logbook and research sampling data, a number of conclusions can be drawn. One conclusion is that the low CPUE is due to weak recruitment to the fishery at Maro Reef and heavy fishing pressure at Necker Island and Gardner Pinnacles. (The weak recruitment to Maro Reef is likely due to environmental events.)

Another conclusion is that the spawning potential ratio of 0.40 indicates that, if recruitment to the fishery were average, the fishing effort in 1990 would not be considered excessive. However, the spawning biomass index based on CPUE estimated the 1990 level at 22% of the pre-fishery level; this indicates that with the low level of recruitment to the fishery in 1990, 1.2 million trap-hauls may have been excessive. It should be kept in mind that the 1990 spawning biomass is the lowest yet observed, and the recruitment to the fishery from the 1990 spawning biomass will not be observed until 1993.

The stock assessment also reveals that two actions can protect the current spawning biomass and promote the recovery of the annual CPUE to 1.0 in 1991: the fishery could be closed from January through August to protect the spawning population; and annual fishing effort could be limited to ≤200,000 trap-hauls, which can be adjusted upward to 400,000 trap-hauls if Maro Reef experiences normal recruitment in 1991.

Although the assessment indicates that a maximum sustainable yield of 0.9 million lobster with 0.9 million trap-hauls still appears appropriate, this is a long-term average and considerable year-to-year variation can occur. It is important that fishery managers be able to regulate catch or effort annually to protect the population in poor years. (J. Polovina (808) 943-1218)

Juvenile Opakapaka Habitat Studied

As part of an effort to obtain a predictive index for recruitment of commercially valuable deep-water snappers, a 17-month field study of the habitat of juvenile opakapaka *(Pristipomoides filamentosus)* outside Kaneohe Bay, Oahu, was completed in February 1991, according to Fishery Biologist Robert B. Moffitt. At this location, juvenile opakapaka of 8-25 cm fork length (FL) inhabit a featureless plain at depths between 65 and 100 m. Bottom samples and video footage show the bottom to be uniformly composed of fine, silty sand with very little relief. Conductivity-temperature-depth (CTD) casts taken at this habitat show that an internal tide crosses over

this area, causing temperature fluctuations of at least 2°C on the bottom (Figure 2). It is not known whether this internal tide is utilized as a transport mechanism either for juvenile opakapaka settlement or for prey item transport.

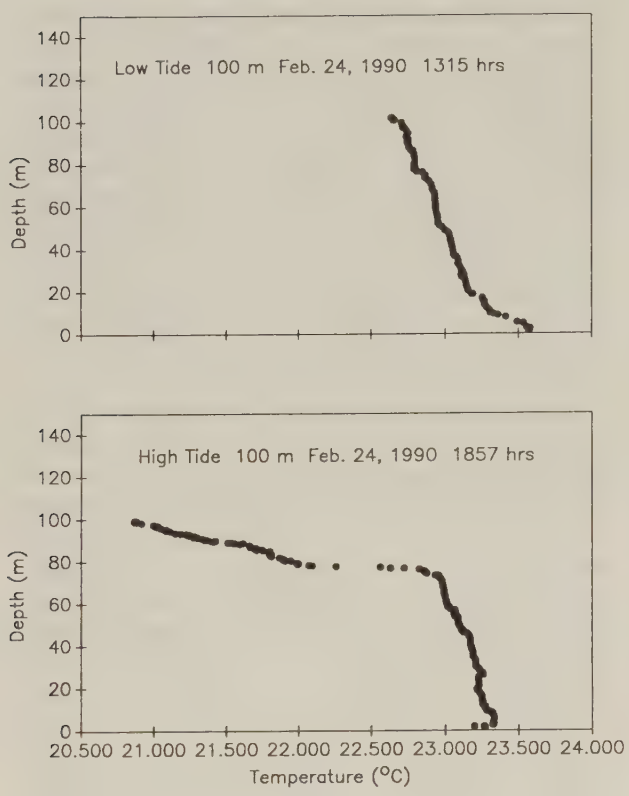

Figure 2. CTD casts showing effects of an internal tide on juvenile opakapaka habitat.

Sonic tracking data from a 19 cm FL juvenile opakapaka, monitored over the 5-day life of the transmitter, suggest that these fish undergo a diurnal migration. This migration is not linked to the temperature fluctuation caused by the internal tide, but rather, is crepuscular in nature. The 19 cm FL fish moved daily at sunset from a day position (at a depth of 85 m) to a night position (at a depth of 75 m); it returned to the day position at dawn. Movement during either the day or the night was very limited (<0.25 nautical miles (nmi)), whereas the day and night positions were located about 0.5 nmi apart. This migratory behavior mimics that of the adults reported to move over the bottom from day depths between 120 and 160 m, to night depths between 30 and 50 m.

Length-frequency information, obtained from 13 sampling periods taken at 4- to 8-week intervals, was used to estimate growth of juvenile opakapaka from the 1989 year class (YC). Using ELEFAN (a computerized program for estimating growth) and restricting L_∞ to 79 cm resulted in an estimate of the instantaneous growth constant (K) of 0.21; this is well within the reported range of estimates for other snapper species. Comparison of the size-frequency distributions (Figure 3) from February of 1990 and

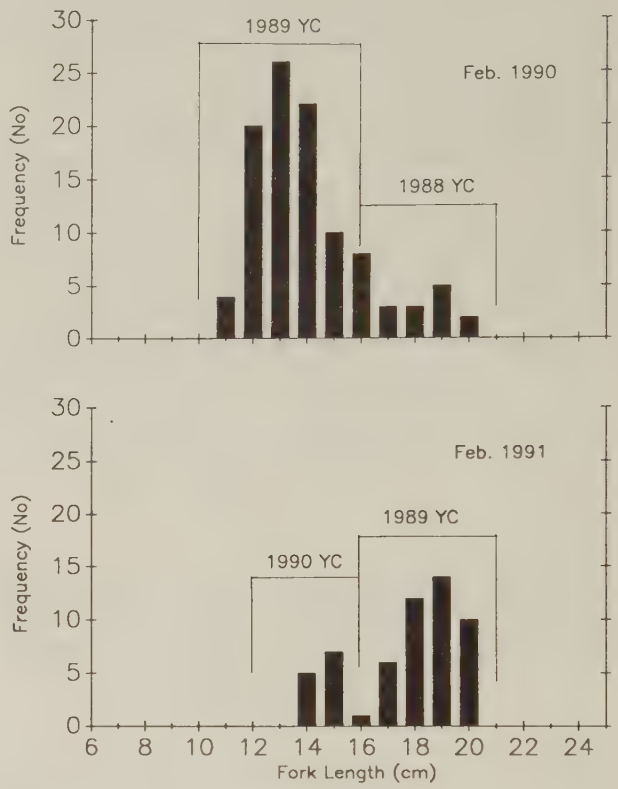

Figure 3. Length-frequency distributions for February 1990 and February 1991.

1991 indicates that recruitment strength can vary considerably between years. At present, there is no way of determining whether the 1989 YC was particularly strong, or the 1990 YC was particularly weak. This difference in year class strength was also noted in the CPUE during the two sampling periods (103 fish caught on 1 day in February 1990 versus 55 fish caught on 2 days in February 1991). However, because of bias introduced through variations in catchability with varying fishermen and weather conditions, CPUE may not be a good quantitative measure in this case. (R. Moffitt (808) 943-1236)

PELAGIC RESOURCES INVESTIGATION

Scientists Conduct Swordfish Longline Research Cruise

The biology and ecology of swordfish were investigated during Leg I of the NOAA Ship *Townsend Cromwell* cruise 91-01 (TC-159) from January 4 to February 2, 1991. This research is in response to the paucity of scientific information on swordfish in the Pacific, and to the growing need for information on the recently established Hawaiian longline swordfish fishery, which has contributed to the great expansion of the longline fleet in the last 2 years. Longline operations were conducted over submerged banks windward of Necker Island, French Frigate Shoals, and Gardner Pinnacles, as well as over seamounts north of Gardner Pinnacles and in the Musicians Seamounts (Figure 4). Honolulu Laboratory participants included Field Party Chief Robert A. Skillman, Fishery Biologists Randolph K. C. Chang and James H. Uchiyama, and Biological Technician Linda A. Koch.

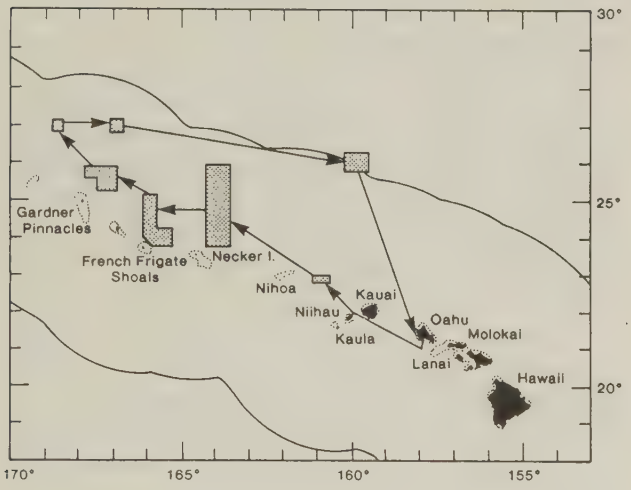

Figure 4. Track and longline sampling areas occupied on Leg I on *Townsend Cromwell* cruise 91-01 (TC-159), January 4 to February 2, 1991.

Laboratory staff collected otoliths, dorsal and anal fin spines, and cephalic and caudal vertebrae for age and growth studies. Gonad samples and data were collected for the study of maturation. Cross sections of bills and hypural plates were collected, and morphometric measurements were recorded (posterior edge of the eye orbit fork length, lower jaw fork length, tip of the bill fork length, several truss measurements, and body depth and half-girth at two different sites) for the study of stock structure. The latter data and weight measurements were also collected to facilitate converting size measurements taken from partially processed swordfish landed by commercial boats to more scientifically useable units. In addition, marking and tagging operations were conducted to further the research on age, growth, and stock structure. During the cruise, 10 swordfish and 2 striped marlin (*Tetrapturus audax*) were injected with oxytetracycline before they were tagged and released. Also tagged and released, using tags provided by Fishery Biologist James Squire from the Pelagic Fisheries Resources Division of the La Jolla Laboratory, were: four swordfish; one striped marlin; six bigeye tuna (*Thunnus obesus*); five yellowfin tuna (*Thunnus albacares*); and one mahimahi (*Coryphaena hippurus*).

Honolulu Laboratory staff also investigated habitat utilization by swordfish by attaching time-depth recorders to the main line of the longline gear and utilizing hook timers attached to individual hook droppers. In addition, temperature and salinity profiles in the area of the longline operations were determined utilizing expendable bathythermographs and conductivity-temperature-depth casts and continuously recording surface thermosalinographs. Current information was collected using an acoustic Doppler current profiler.

To supplement the research capabilities of the Honolulu Laboratory, collaboration was established with Barbara Block of the University of Chicago, and Murray D. Dailey from California State University at Long Beach. Because east coast fishermen entering Hawaii's fishery have reported that Pacific swordfish have a very high parasite load compared with Atlantic swordfish, and NMFS observers on commercial swordfish boats in Hawaii have also reported on the poor condition of some parasitized fish, Patrick Frost, a graduate student from California State University at Long Beach collected parasite specimens from swordfish and from other pelagic fishes for further analysis. For stock structure analysis, the mtDNA-rich heat exchanger organ, located along the ocular nerve in swordfish, was collected from swordfish by John Finnerty, a University of Chicago graduate student, and Soo Young Kim, a laboratory technician also from the University of Chicago. This material will be used to further the physiological and developmental research that Block is conducting on this organ. Similar tests have been conducted by Block on material collected in the Atlantic and Mediterranean. (R. Skillman (808) 943-1257)

FISHERIES MANAGEMENT RESEARCH PROGRAM

Hawaii Swordfish Observations Reported for 1990

The report entitled "A summary of swordfish (*Xiphias gladius*) longline observations in Hawaii, July-October 1990," was recently completed by Biological Technicians Robert A. Dollar, Russell Y. Ito, and Kevin C. Landgraf, and Fishery Biologist Kurt E. Kawamoto (SWFSC Admin. Rep., Honolulu, H-91-03). Their report is in response to the demand for information on a fishery that has experienced tremendous growth since its beginning in 1988: less than 50,000 pounds of swordfish were landed in Hawaii in 1988, increasing to 650,000 pounds in 1989, and probably exceeding 2.5 million pounds (1,134 tons), worth over $7.5 million, in 1990. The vast majority of the swordfish was landed as a headed, gutted, fresh product which is then transshipped to the U.S. mainland, particularly on the east coast.

Early in 1990, the potential for interaction between the expanding swordfish longline fishery and various protected species, particularly Hawaiian monk seals (*Monachus schauinslandi*), and various marine turtles and seabirds, became apparent. With very little known about the fishery itself, the Honolulu Laboratory, using some fiscal assistance from the NMFS Southwest Region, fielded six observers on a voluntary basis aboard swordfish longline vessels fishing in Hawaii's waters in the summer and early fall of 1990. Late in 1990, emergency regulations were approved, making such observer coverage obligatory (subject to the availability of Federal observers and other conditions) in a special "study zone" within 50 miles of the NWHI.

Of the six vessels which received observers, four were east coast swordfish longliners that had recently arrived in Hawaii, and two were Hawaii-based longliners--one having fished tuna in the main Hawaiian islands (MHI), and the other having fished tuna primarily outside the MHI. Placement of observers was voluntary through agreements with individual vessel captains and owners, with the understanding that information on individual trips would be kept confidential. Cooperation by the captains during the trips was excellent.

The six longliners, ranging in size from 63 to 88 ft, fished three areas: NWHI, MHI, and mid-Pacific waters (primarily north of Hawaii). Only one vessel fished in the MHI and NWHI; therefore, no data on the fishing operations by area can be provided. Trip lengths varied from 11 to 23 days. The vessels used between 20 and 50 miles of 3.0-4.0 mm monofilament main lines. Hooks were baited primarily with large, whole squid (300-400 g). The number of hooks deployed varied substantially (400-1,800 per set), within a trip. Light sticks of various colors were attached with rubber bands to branch or dropper lines. All vessels initially targeted swordfish; however, during the last three observer trips, catches of market-sized swordfish were so low that the vessels shifted their attention to bigeye tuna (*Thunnus obesus*), using the same gear and minimal changes in technique. Observers collected catch and effort data, biological measurements, as well as information on protected species interactions and fishing operations.

No interactions with protected species occurred in the MHI, but some occurred in the NWHI and mid-Pacific. No monk seals were sighted in any area. A solitary killer whale (*Orcinus orca*) was observed in mid-Pacific waters on one set in which most of the catch was damaged--only heads and jaws remained on the hooks. The vessel moved to another location, and no further sightings were observed. No negative impact on the whale was apparent. Porpoises were also seen in the vicinity of the gear during one NWHI set, but no physical interaction was seen.

In the NWHI, two large leatherback turtles (*Dermochelys coriacea*) were entangled in the fishing gear and released alive. In each case, the leader was cut as close to the hook as possible while the turtle remained in the water. (Both turtles were too large to bring on board, and handling the turtles was discouraged.)

In both the mid-Pacific and NWHI, there were incidents involving albatrosses (*Diomadea nigripes* and *D. immutabilis*). In each case, the birds were observed attacking the bait (squid) as the line was set. Two birds were hooked and drowned. Thereafter, both vessels took precautionary measures to sink the bait more rapidly, and this was evidently successful, as no further birds were found hooked.

The largest numbers of components comprising the catch consisted of blue sharks (*Prionace glauca*), which were generally cut loose, followed by swordfish, mahimahi (*Coryphaena hippurus*), and bigeye tuna. The mean size of measured swordfish from eye orbit to fork of tail (N=339) was 130.5 cm. The biological information acquired on these trips will be further analyzed by the Pelagic Resources Investigation of the Honolulu Laboratory. (S. Pooley (808) 943-1216)

Report Maps the Political Geography of Albacore Tuna Management

Donald M. Schug, formerly of the Honolulu Laboratory and now a graduate student in the University of Hawaii's Department of Geography, recently completed a manuscript titled "The prospects for an international fisheries management regime for South Pacific albacore (*Thunnus alalunga*)" (SWFSC Admin. Rep., Honolulu, H- 91-02); it will be submitted for publication in a peer-reviewed journal. Schug's report evaluates the current interest in establishing an international management regime for the South Pacific albacore fishery. Such interest increased, particularly for South Pacific island countries and U.S. and New Zealand troll fisheries, as a result of the expansion of distant-water drift-net fishing in the mid- and late-1980s. His report also reviews various international arrangements for fisheries management in the South Pacific. Although a number of problems may frustrate the negotiation efforts by the Pacific island states and the distant-water fishing nations, current institutional arrangements encourage a solution to the albacore management problem.

Drawing from literature on the political economy, Schug evaluates the prospects for an international management regime in light of a conceptual model of cooperative strategies in international negotiation. For international agreements subject to "uniformity rules" (i.e., any nation can reject the proposed agreement unilaterally), such models view each participant in negotiations as a self-interested maximizer of gains for his or her nation. Within this spectrum, there are six conditions that must be considered:

1. Whether the issues at stake lead to "contractarian interactions" (i.e., whether both sides of the negotiation hold rights that can be exchanged, but whose terms of exchange may be hard to determine in advance). It is difficult to present South Pacific albacore negotiations in such terms because of the widely divergent interests of the participants (the South Pacific island countries and the distant-water fishing companies and nations). However, because both parties share common interests, such as increasing scientific information on albacore as a biological stock, this may provide the initial focus for agreements. Ultimately, the South Pacific island nations will be interested in fees for access, while the distant-water fishing companies will want to ensure continued access to fishing rights within the exclusive economic zones of these nations.

2. Whether equitable arrangements for bargaining exist. Central to this issue is recognition by both parties that the standard economic efficiency arguments probably are entirely secondary to the fair distribution of the resource "rents" from harvesting highly migratory albacore stocks. In this, previous agreements for other South Pacific fisheries make agreement for albacore more likely.

3. Whether salient solutions exist (i.e., whether institutional arrangements can actually be concluded once the idea of agreement is accepted). The transaction costs may be substantial in establishing means for collecting and distributing access fees and in allocating access rights to the distant-water fishing companies and nations. Such solutions may be made possible through simple rather than complex terms, amendment of existing fishing agreements, or utilization of existing fisheries institutions.

4. Whether compliance mechanisms exist. Individual island nations cannot afford substantial enforcement capabilities, and even collaborative efforts may be limited. However, such compliance mechanisms are made less costly by the existence of a regional "register" of permitted and black-balled fishing vessels, as well as agreements by metropolitan countries such as the United States, Australia, New Zealand, and Japan, to police the agreement.

5. Whether there are exogenous shocks or crises which would increase the likelihood of success. In this case, the existence of drift gillnet fishing vessels was the exogenous shock which brought most of the parties together. With the decision by most of the distant-water fishing nations to remove their driftnet fleets from the South Pacific, that focus was also removed. The question remains whether the other conditions have developed sufficiently that agreements can be achieved without this feature.

6. Whether effective leadership will emerge to support such negotiations. The role of the Forum Fisheries Agency (FFA), an organization of 16 independent South Pacific nations, is viewed as critical to the establishment of formal treaties. The FFA played a key role in developing the South Pacific tuna treaty with the United States in 1987; by controlling U.S. purse seine access to South Pacific fisheries, this treaty broke new ground in such international fisheries agreements. At present, the South Pacific albacore research group, an informal organization including FFA and distant-water fishing nations, and other regional organizations, is

playing a central role in pooling scientific information on the albacore fishery. How this group develops is central to the future of an international agreement on albacore.

Schug's report does not predict the ultimate outcome of such negotiations, but it does conclude that the Law of the Sea's entreaty, that nations cooperate on joint conservation and management of fishery resources, will not come to fruition without work. Anticipation of the results of such negotiating work might be facilitated by continued examination of the six conditions identified in Schug's report. (S. Pooley (808) 943-1216)

PACIFIC FISHERIES ENVIRONMENT GROUP

Monterey, California

Co-occurrence of Elevated Temperatures in the California Current Region and Tropical El Niño-Southern Oscillation Activity

California Current regional warming events sometimes occur in the same years as tropical El Niño warming. In these cases they have been called Californian "El Niño" events. Regional warming events also may occur in years when there is no apparent connection with the tropical ocean. These appear in association with anomalous atmospheric circulation over the North Pacific Ocean, which frequently includes intensification of the Aleutian Low atmospheric pressure system. For instance, the anomalous coastal warming during 1990, based on preliminary analysis, appears closely related to anomalous atmospheric conditions over the northeastern Pacific Ocean. However, this report focuses on the apparent relation between California Current warming events and tropical ocean-atmosphere activity.

Tropical El Niño events or El Niño-Southern Oscillation (ENSO) ocean warming phases appear associated with the quasi-periodic slackening of trade winds blowing from east to west over the equatorial Pacific (Southern Oscillation). Sea level atmospheric pressure at Darwin, Australia, provides an indication of Indonesian Low pressure system development and an index of SO activity. When equatorial trade winds slacken, as indicated by an increase in barometric pressure at Darwin, oceanic downwelling and warming disturbances propagate eastward toward South America. Oceanographer Jerry Norton is investigating relationship between indicators of ENSO activity and indicators of seasonal scale temperature change in the Northern Coastal California Current region.

Both the ocean temperature and ENSO indicators used in the correlation analysis represent interannual change of difference parameters. The interannual difference value for the current year is found by subtracting the value for the previous year from the value for the current year. If

$$D_n = A_n - A_{n-1},$$

then D_n is the interannual difference value for the "nth" year, and A_n is the anomaly compared to a long term mean. In a physical sense, this difference represents the summation of all shorter term anomaly changes for the intervening period. Each anomaly change represents the combination of physical processes occurring within the differencing interval that will affect the anomaly, A_n. If A_n is considered an indication of the energy content or state of a system, then D_n would represent a change in state of the system occurring from n-1 to the same period in n.

Since the interannual difference is just a special case of the familiar backward difference transform of stochastic processes modeling nonstationary series, its use has the advantage of removing multiyear trends from the data series. Consequently, the interannual difference series has been filtered so that signals occurring on annual and biannual scales are enhanced.

In deriving the interannual difference time series, both oceanic and atmospheric data were combined into 6 month periods. The oceanic data were averaged spatially, and the atmospheric pressure data were from a "center of action." Statistical studies have shown "centers of action" or "key areas" to be representative of much larger geographical areas. Surface barometric pressure for the center at Darwin, Australia, is highly correlated with a surrounding area of thousands of square kilometers over the western equatorial Pacific Ocean. Additional information on data processing may be obtained from the March-April 1990 SWFSC Report of Activities.

The correlation between Darwin sea level pressure and northern California Current ocean temperature change is shown in Figure 1. A broad band of r values exceeding 0.6 ($p<0.01$) is seen to extend from the surface to at least 300 m (shaded).

From Figure 1, positive values indicate correlation with the warming ENSO phase. The time intervals used for each composite ocean temperature measurement were marked with a solid dark bar at the top and bottom, and ocean interannual differences were taken from the fourth month of this interval. The oceanic variable is depth (vertical) and all ocean interannual temperature change values are from the same September through February period. Atmospheric variables are variable in time from January through December of the nominal year (yr, left) and for the following year (yr +1, right). The center vertical line marks December 31 of the nominal year (yr), while solid and dashed contours denote positive and negative correlation, respectively.

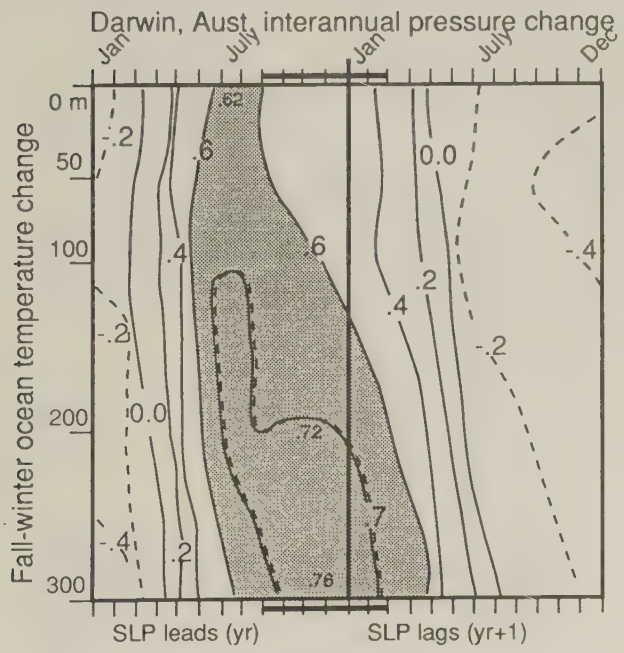

Figure 1. Correlation response surface for fall-winter interannual ocean temperature change parameter at 0, 50, 100, 200, and 300 m, and monthly values of the interannual atmospheric pressure change index for the ENSO activity.

Several trends are evident. First, the correlation coefficients increase with depth from 0.65 at the surface to more than 0.75 at 300 m. Second, the r>0.6 band increases in width from 3 months at the surface to 9 months at depth. Third, the largest coefficients occur in July and August at 200 m and shallower, and in October through January at 300 m. Equatorial forcing appears to precede temperature change at 200 m by about 5 months. The apparent lag of the northern coastal California Current regional response behind equatorial atmospheric forcing suggests a causal connection to ENSO conditions. Fourth, coherent negative correlation leads and lags the fall and winter season. This may reflect a biannual El Niño period.

The co-occurrence of warming in the California Current region and the tropical Pacific Ocean is the result of widespread, mid-latitude atmospheric adjustment to ENSO events. Furthermore, it is probably mid-latitude atmosphere-ocean interaction that is responsible for widespread Californian "El Niño" warming.

However, Norton bases his analysis on the extreme 1982-1983 warming event which may not be completely typical. Continuing research will be designed to investigate the relation of Californian "El Niño" events to warming events, such as the 1990 event, that apparently occur without warm phase ENSO activity. (J. Norton (408) 646-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Comparison Made of U.S. Eastern Tropical Pacific Tuna Purse Seine Day and Night Set Mortality Rates

Mathematical Statistician Al Coan, Computer Programmer Analyst Ken Wallace, and Fishery Biologist Alan Jackson completed a paper that describes differences in dolphin mortality rates in day and night sets for U.S. purse seiners fishing in the eastern tropical Pacific (ETP). This paper is an expansion of an earlier one on the same subject. Analyses with geographic stratification of sets (Figure 1) are included in this expanded study.

During the period 1979 to 1988, 21,000 dolphin sets and an associated dolphin mortality of 84,000 animals were observed by scientific observers aboard U.S. purse seiners fishing in the ETP. Approximately 67% of the sets and 49% of the dolphins killed occurred in area I, 16% of the

sets and 19% of the animals killed occurred in area II, and 17% of the sets and 32% of the animals killed occurred in area III.

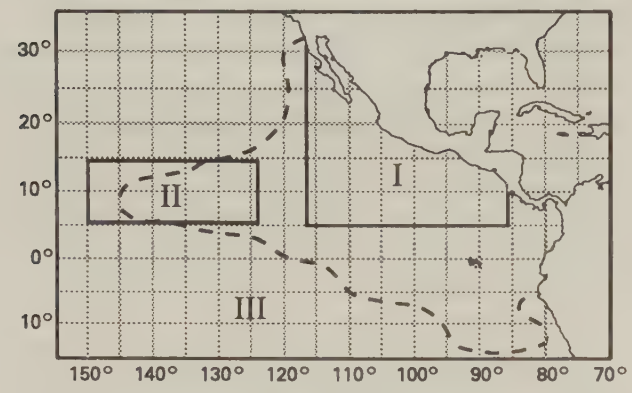

Figure 1. Area of the eastern tropical Pacific where yellowfin tuna are caught in sets associated with dolphins, and three sub-areas used to stratify dolphin mortality rates of U.S. purse seiners participating in the fishery.

Night sets, while accounting for only 10% of the dolphin sets and 30% of the dolphin mortality, consistently killed dolphins at a higher rate than day sets in all areas of the ETP (Figure 2). Only in area II did mortality rates for night sets ever fall below day set rates. The average number of dolphins killed per set (kill/set) and per ton of yellowfin tuna caught (kill/ton) in night sets, was approximately 3 to 4 times that in day sets for all areas of the ETP. Mortality rates were the highest in area III. Night sets also had consistently lower percentages of sets with no dolphins killed (zero-kill sets) and higher percentages of sets with more than 15 dolphins killed (high-kill sets) compared to day sets. A Wilcoxon paired-sampled test was used to test if these differences between day and night sets were statistically significant. Results indicate that mortality rates, as well as percentages of high-kill sets, are significantly higher (5% probability level) in night sets than in day sets; and the percentages of zero-kill sets are significantly lower in night sets than in day sets. Stratification of the data by area did not change these results.

High-intensity floodlights have been used during night sets by U.S. purse seiners since 1982 and became mandatory equipment for all vessels in 1986. The use of these floodlights during the period 1982 to 1988 decreased mortality rates as much as 77% over sets using other types of light (i.e. low-intensity lights). However, even with the use of floodlights, mortality rates were not lowered to parity with day set mortality rates.

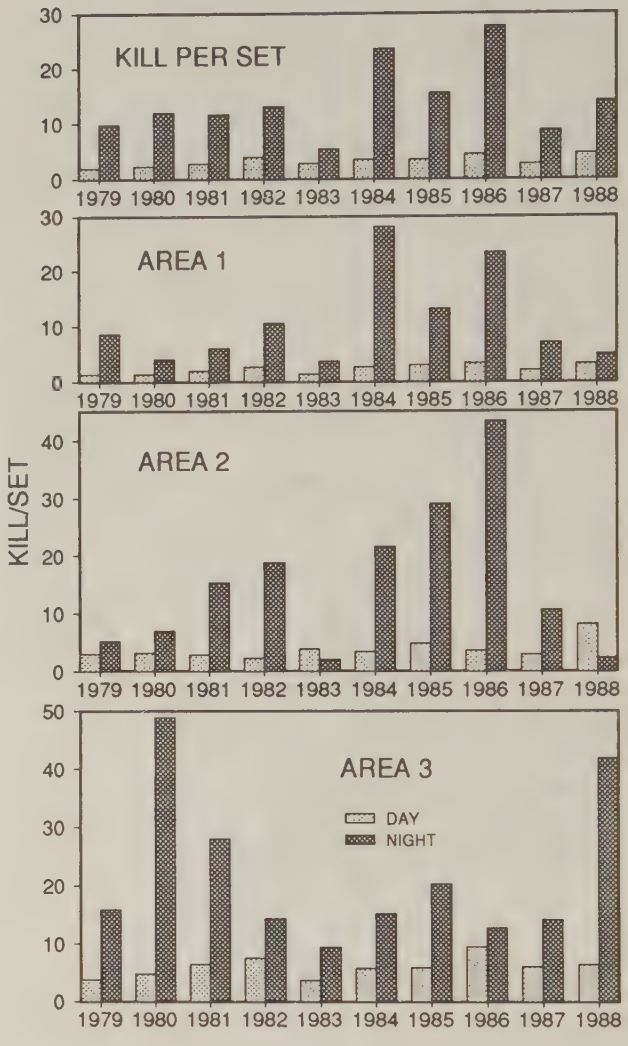

Figure 2. Dolphin mortality rates (dolphins killed per set) in day and night sets of U.S. purse seiners fishing in the eastern tropical Pacific, 1979 to 1988.

In order to assess the effects of prohibiting night sets on mortality rates, all sets (day and night combined) during the period 1979 to 1988 that started after various times, were eliminated. Times considered were sundown and 15, 30, 45, 60, 75, and 90 minutes before sundown. Average mortality rates for all remaining sets were recalculated and compared to average mortality rates before any sets were eliminated. Results showed that average mortality rates decreased approximately 6 to 20%. Total mortality decreased as much as 30% and catches 13%. (A. Coan, FTS 893-7079)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Albacore Loss Rates from Drift Gillnets Experimentally Studied

The drop out rate of albacore from a high seas drift gillnet was measured experimentally in a wave tank facility during February. One tank of commercially bought, 175 mm stretch-mesh drift gillnet (the same type used by Asian fishermen), was "fished" in a large wave and towing basin at ARCTEC Inc., in Escondido, California. This wave basin is 350 feet long, 50 feet wide, 13.5 feet deep, and it holds 1.3 million gallons of water. Through the use of a sophisticated, computer-controlled wave generation package, it is capable of simulating full size wind driven seas corresponding to up to 23 knots (kn) of wind.

Dead albacore were placed in the net by SWFSC divers, and then the net was subjected to full scale wave spectrums typical of wind driven seas during spring in the transition zone of the north Pacific Ocean. This included seas corresponding to wind speeds between 8 and 23 knots, with varying wave periods. In addition, the net was subjected to regular periodic swells of varying heights. A total of 14, 30-minute runs was made with albacore gilled in the net. Loss rates ranged from 0 to 70% and showed an increasing trend with increasing wave energy levels. The results are currently being analyzed. (N. Bartoo, FTS 893-7073; D. Holts, FTS 893-7186)

PELAGIC ECOSYSTEM MODEL DEVELOPMENT PROGRAM

Japanese Albacore Data Confirms Population Decline Deduced from U.S. Data

Pierre Kleiber worked with Hideki Nakano from the Japanese National Research Institute of Far Seas Fisheries to analyze catch and effort data from the Japanese North Pacific albacore pole-and-line fleet. The object was to see if they would find the same diverging trend between two methods of calculating catch per effort as reported by Pierre Kleiber and William Perrin (1991) for the U.S. jig fleet during the 1980s. Kleiber and Perrin found that the divergent trends resulted from the fact that U.S. fishermen were improving their ability to find albacore concentrations during the 1980's. This caused upward biases in the trends of both catch per effort time series. Because one of the catch per effort measurements had a slightly downward trend, the actual population trend must have been an even steeper decline. Because the Japanese and U.S. fleets depend at least to some extent on the same biological population of albacore, it was felt that the Japanese data could confirm the results from the U.S. data.

The two types of catch per effort are pooled and semi-stratified, and given by

$$cpe_{\text{pooled}} = \frac{\sum c_i}{\sum e_i}$$

$$cpe_{\text{semi-strat}} = \frac{1}{N}\sum\left[\frac{c_i}{e_i}\right]$$

where c_i and e_i are the catch and effort in the i-th stratum, and N is the number of strata. The two catch per effort time series for the Japanese data are shown in Figure 3. The pooled catch per effort appears to trend upwards while the semi-stratified catch per effort remains relatively constant, and approximates the results from the U.S. data (Kleiber, P. and C. Perrin. 1991. "Catch per effort and stock status in the United States North Pacific albacore fishery: reappraisal of both." Fish. Bull., U.S. 89).

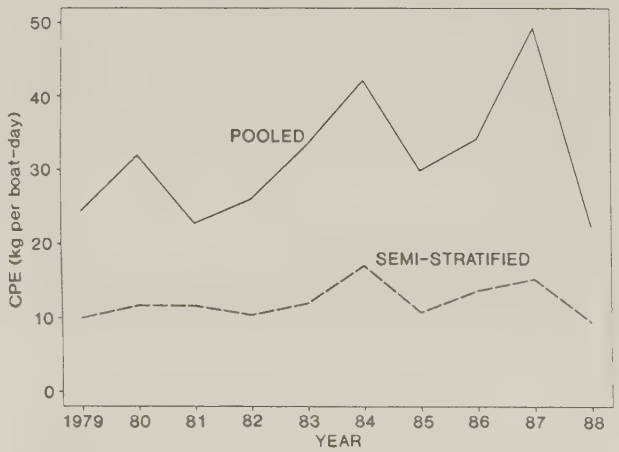

Figure 3. Japanese baitboat catch per effort time series for North Pacific albacore: pooled (solid line) and semi-stratified (dashed line).

To check for evidence that the pole-and-line boats were increasingly concentrating on areas rich in albacore, a "favoritism index" was calculated. This index is the proportion of the effort in any year that is expended in strata with a catch per effort

above some threshold value, *cpe**. The favoritism index in year *y* is given by

$$favoritism_index_y = \frac{\sum_{i \in T_y} e_i}{\sum_{i=1}^{N_y} e_i}$$

$$T_y = \{i \mid (c_i/e_i) \geq cpe_y^*\}$$

where T_y is the set of stratum indices for which *cpe* is greater than cpe_y^*, and cpe_y^* is a threshold for the top 20th percentile (ranked by catch per effort) of strata in each year *y*. The increase in favoritism is not as dramatic for the Japanese fleet as for the U.S. fleet (Figure 4), but the trend is the same; this indicates rising positive biases in both cpe_{pooled} and $cpe_{semi\text{-}strat}$ time series.

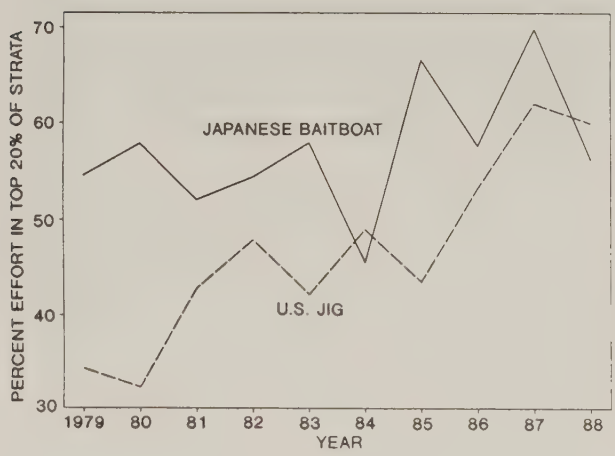

Figure 4. Index of favoritism for concentrations of North Pacific albacore: Japanese pole-and-line boats (solid line) and United States jig boats (dotted line). (U.S. data from Kleiber and Perrin, 1991).

If a parallel rise in both pooled and semi-stratified catch per effort had been found instead of a divergence, as seen in the U.S. data, it would have cast doubt on the notion that Japanese and U.S. surface albacore fisheries in the North Pacific are harvesting the same biological population. But this study's results are similar to the results from the U.S. data, and are therefore consistent with the notion of a shared resource. Furthermore, the results of this study carry the same implication as the U.S. data, namely that the resource has been in decline during the 1980s. (P. Kleiber, FTS 892-7076)

Optimal Strategy by Dolphins for Detection Avoidance

It is well known that certain species of dolphins attempt to avoid detection when a vessel approaches, by fleeing. The species *Lagenodelphis hosei* is so successful in this endeavor that knowledge of its occurrence and distribution range is incomplete.

Because of the implication of this behavior to dolphin census methods using ship sighting surveys, Carlos Salvadó, Pierre Kleiber, and Andy Dizon, at the La Jolla Laboratory, constructed a sighting model that asks the following: If a vessel approaches at speed V_B, in what direction must a dolphin go at speed V_D in order to maximize its distance from the vessel at the point of closest approach? The answer to this question is that the angle between the velocity of the vessel and that of the dolphin must equal $\arccos(V_D/V_B)$. This model is being tested using data from eastern tropical Pacific dolphin surveys. (C. Salvadó, FTS 893-7052; P. Kleiber, FTS 893-7076; A. Dizon FTS 893-7089)

TIBURON LABORATORY

Tiburon, California

DIRECTOR'S OFFICE RESEARCH

Further Analysis of Salmon Management Options

The proposal to mark all Klamath Basin hatchery fish and subsequently manage hatchery and natural stocks separately, has run into further obstacles. A review of marking studies by the Klamath River Technical Advisory Team produced estimates of delayed marking mortality ranging from 20 to 50%. Further fishery simulations incorporating delayed marking mortality of 20% for hatchery fish indicate that an increase in mortality of this magnitude would cancel out the modest increases in harvest that could result from refinements in management.

Salmon fisheries may have a disastrous year in 1991. In addition to restrictions placed on fishing seasons to protect the threatened Sacramento River winter run of chinook, the fall run of Klamath River chinook reached an all-time low in 1990. The spawning escapement for the entire basin was estimated at 8,100 adult spawners returning to the hatcheries and 12,400 adult fish

spawning naturally. The average escapement for the years 1978 through 1989 was 16,500 adult spawners at the hatcheries and 49,000 adult natural spawners. The current management plan calls for a minimum of 35,000 naturally spawning adults in the basin. The forecasted abundance of Klamath basin adults for 1991 is only 44% of the forecasted abundance in 1990, and will require major reductions in fishery impacts if the present escapement goal is to be met. (R. Kope, FTS 556-0565)

GROUNDFISH COMMUNITIES INVESTIGATION

Study Indicates Problems with Coastwide Trip Limits in Lingcod Management

Trip-limits for west coast groundfish typically are set coastwide, but analysis of the PacFIN Research Data Base by Peter Adams and Kelly Silberberg suggests that this practice would be inappropriate for lingcod. Their findings indicate that coastwide trip limits would evoke highly varied responses within the region because of major geographical differences in the fishery. A coastwide trip limit of 30,000 pounds would reduce overall landings by 4% and affect less than 1% of the trips, while a limit of 1,000 pounds would reduce overall landings by 40% and affect 13% of the trips. Considering each INPFC area within the region separately, however, we find that local responses to these trip limits differ (Figure 1). Thus, the 30,000 pound limit would reduce the Vancouver landings by 14% and the Columbia landings by 1%, but would not affect the Eureka, Monterey, or Conception landings. And the 1,000 pound limit would reduce the Vancouver landings by 68%, the Columbia landings by 57%, and the Eureka, Monterey, and Conception landings by 39, 36, and 29%, respectively.

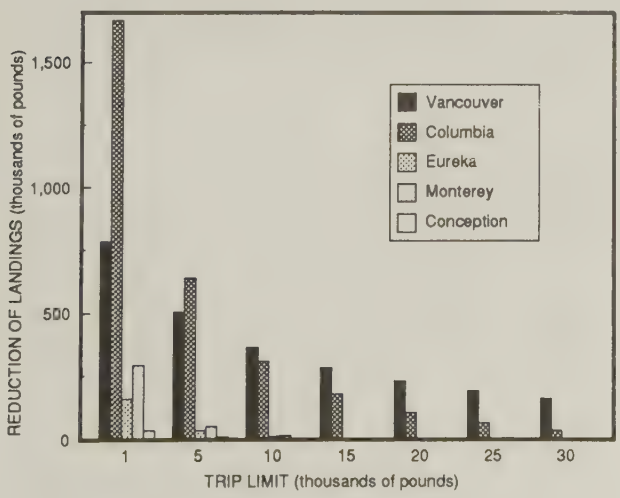

Figure 1. Expected results of different coastwide trip limits on lingcod landings in each INPFC area.

Because it is known that lingcod landings decrease sharply southward, it could have been predicted that there would be local variations in response to coastwide trip limits. Nevertheless, it is important to keep this variation in mind when developing a management plan for the species. (P. Adams, FTS 556-0565)

GROUNDFISH ANALYSIS INVESTIGATION

Larval Production of Shortbelly Rockfish Studied to Estimate Spawning Biomass

Members of the task recently completed an ichthyoplankton survey targeting shortbelly rockfish (*Sebastes jordani*) along the central California coast between Cypress Point (Monterey County) and Point Reyes (Marin County). Sampling was concentrated in the vicinity of Ascension Canyon and offshore of Pescadero. Shortbelly are quite abundant in both areas but are not currently harvested. The stock is believed to represent a resource of considerable commercial potential, and is ecologically quite important in the diets of salmon and seabirds.

The survey was completed from February 6 to 19 aboard the *David Starr Jordan*. The sampling plan called for Bongo net tows at 153 stations from nearshore waters to over 70 miles offshore. Upon completion of the cruise, over 200 collections had been made in a 9 1/2-day period. Standard CalCOFI sampling protocols were utilized, except that tows were restricted to depths ≤141 m (as opposed to 212 m) to increase the number of stations occupied, and to develop a better understanding of the depth distribution of shortbelly larvae during their first few days in the plankton. An additional series of oblique Bongo tows to depths of 92, 141, and 191 m was obtained at the end of the cruise.

Although the samples have yet to be fully sorted and the fish species identified, preliminary results indicate that the larvae of shortbelly rockfish greatly outnumbered all others. They were particularly numerous in the northern part of the study area in the vicinity of Pioneer Canyon and on the continental shelf offshore of Pescadero.

Work aboard the *Jordan* was coordinated with a simultaneous 4 day charter of the F/V *New Janet Ann*, which was contracted to obtain samples of the adult portion of the stock. Sam-

pling aboard the chartered vessel was designed to evaluate differences in the biological characteristics of adult shortbelly rockfish samples obtained at different geographic locations (Pescadero or Ascension Canyon), in different depth strata, and by different gears (midwater or bottom trawls).

The primary objective of the larval survey is to estimate the number of day-0 shortbelly rockfish in the study region. To accomplish this goal, the staff expects to age at least 1,000 larvae using daily otolith increments, to estimate spawning biomass. The data will be analyzed in conjunction with information obtained from the adult portion of the population. In particular, size and age composition data, sex ratio, maturity schedules, and fecundities are also being studied by the staff at the Tiburon Laboratory.

Due to the broad range of issues being analyzed, there has been extensive cooperation among the three research tasks at the laboratory. For example, personnel from the Groundfish Physiological Ecology Investigation participated in both cruises and will determine the relationship between shortbelly size and fecundity. Since the inception of the study, their expertise concerning the reproductive biology of rockfishes has proven valuable in the study design as well. Likewise, personnel from the Groundfish Communities Investigation will assist in identifying the larvae obtained.

A secondary objective of the cruise is to study transport processes and how they may alter the distribution of shortbelly rockfish larvae as they grow in size. To assist in this, the newly installed acoustic Doppler current profiler (ADCP) recorded current velocities at various depths throughout the cruise. Initial indications are that the ADCP unit performed admirably. An intercalibration of the ADCP aboard the *David Starr Jordan* with one aboard the R/V *Point Sur* was also completed. In conjunction with the 74 conductivity-temperature-depth (CTD) stations that were completed during the cruise, the ADCP data will provide an indication of the current field to which the larvae were exposed. (S. Ralston, FTS 556-0565)

INFORMATION TECHNOLOGY SERVICES

Conversion of Financial Reporting System to 3COM LAN

The Financial Reporting System (FRS) is an interactive administrative reporting system. It was designed to provide the administrators and task leaders of the Southwest Fisheries Science Center with timely reports of financial and staff year data, to assist in the management and allocation of resources.

FRS is presently operating on the Molecular Supermicro 32X, which will be phased out by mid FY-1991. In meeting the phase-out plan, the FRS system has been converted from dBASE II to dBASE III+ and moved to the 3COM LAN.

In June 1990, Rob Bistodeau converted the FRS commitment modules to run on the 3COM LAN as a prototype for converting the entire system. Susan Jacobson soon joined the effort to convert the remaining data entry modules and the reporting routines. Frank Ralston installed dBASE III+ on the 3COM LAN and set up the connections for high-speed access by remote FRS users. PFEG accesses FRS for data entry and report generation, and the Tiburon and Honolulu Laboratories access it for data transmission and report generation.

During the conversion process, programs were refined and standardized, and in-program documentation was added. To facilitate multi-user access, files were organized among sub-directories according to usage. In the name of efficiency, error trapping routines were also designed and implemented and user interfaces were improved. After preliminary testing, Bistodeau briefed users on the new software, and the data entry modules were put into operation. As part of the final testing of the FRS 3COM LAN version, actual data are being used to generate reports and for parallel testing with the 32X version. (S. Jacobson, FTS 893-7060; R. Bistodeau, FTS 893-7055)

PUBLICATIONS

Published

Balazs, G. H. 1991. Sea turtle tag center of the Pacific. Mar. Turtle Newsl. 52:14-15.

Boehlert, G. W., M. Kusakari, and J. Yamada. 1991. Oxygen consumption of gestating female *Sebastes schlegeli*: estimating the reproductive costs of livebearing. *In*: Boehlert, G. W., and J. Yamada (eds.), Rockfishes of the genus *Sebastes*: their reproduction and early life history. Environ. Biol. Fish. 30(1-2):81-89.

During gestation, live-bearing fishes incur physiological energy costs, including provision of energy and respiratory gases to the developing embryos and removal of waste products. Fecundity in the genus *Sebastes* is high, and the ovaries represent a significant portion of the weight of gestating females. In this study, we compare oxygen consumption of gestating

females with non- gestating females and males of kurosoi, *Sebastes schlegeli*, to estimate these costs. Oxygen consumption by pregnant females is significantly higher than that of males and immature females at similar sizes and weights. We estimate that a 1.5 kg gestating female consumes 68% more oxygen than a non-gestating fish during the 51.5-day period of gestation. Such an increase in oxygen consumption rates may have important implications to the metabolic scope of gestating females. The additional oxygen consumed by gestating females is greater than that predicted for the embryos alone, suggesting that costs of increased gill ventilation, ionic and osmotic regulation and cardiac output are relatively high. Such energetic costs represent a quantifiable expense of the viviparous mode of reproduction in *Sebastes* as compared with oviparous species.

Boehlert, G. W., M. S. Love, J. P. Wourms, and J. Yamada. 1991. A summary of the symposium on rockfishes and recommendations for future research. *In*: Boehlert, G. W., and J. Yamada (eds.), Rockfishes of the genus *Sebastes*: their reproduction and early life history. Environ. Biol. Fish. 30(1-2):273-280.

Significant progress in our understanding of the reproduction and aspects of the early life history of *Sebastes* was evident in the papers presented at this symposium (not all published in this volume). On the final day, we presented short summaries of this progress made in the various research topics--reproduction, embryonic and larval development, early life history, ecology, mariculture and fisheries applications--and considered the questions and discussions raised during the symposium for further research. A discussion session followed. This paper presents the summaries and, to the extent possible, incorporates points made during the discussion session.

Boehlert, G. W., and J. Yamada. 1991. Introduction to the symposium on rockfishes. *In*: Boehlert, G. W., and J. Yamada (eds.), Rockfishes of the genus *Sebastes*: their reproduction and early life history. Environ. Biol. Fish. 30(1-2):9-14.

Boehlert, G. W., and J. Yamada (eds.). 1991. Rockfishes of the genus *Sebastes*: their reproduction and early life history. Kluwer Academic Publ., Dordrecht, The Netherlands, 288 p.

Bowlby, C. Edward, Penelope D. Scoggins, Rodney T. Watson, and Michelle L. Reddy. 1991. Hawaiian monk seal, *Monachus schauinslandi*, at Kure Atoll, 1982-83. U.S. Dep. Commer., NOAA Tech. Memo, NOAA-TM-NMFS-SWFSC-155, 29 p.

Bushnell, P. G., R. W. Brill, and R. E. Bourke. 1990. Cardiorespiratory responses of skipjack tuna, *Katsuwonus pelamis*; yellowfin tuna, *Thunnus albacares*; and bigeye tuna, *T. obesus*, to acute reductions of ambient oxygen. Can. J. Zool. 68:1857-1865.

Heart rate and swimming speed responses to acute hypoxia were measured in skipjack (*Katsuwonus pelamis*) and yellowfin tunas (*Thunnus albacares*). Swimming speeds began to increase in both species when oxygen tension (PO_2) reached approximately 124 mm Hg. Bradycardia became significant in both species when PO_2 reached approximately 130 mm Hg. Heart rate fell with PO_2 in yellowfin tuna, but in skipjack tuna, it increased at the lowest oxygen levels reached (89-70 mm Hg). Bradycardia occurred in both species despite concomitant increases in swimming speed.

A continuous infusion dye dilution system was used to monitor changes in ventilation volume ($\dot{V}_g$) during hypoxia in yellowfin tuna. As PO_2 fell, $\dot{V}_g$ increased. At the lowest oxygen levels (109-90 mm Hg), $\dot{V}_g$ was 45% higher than during normoxia. $\dot{V}_g$ increased despite no concomitant increases in swimming speed.

Data from these experiments were used to develop a model capable of predicting oxygen demand and delivery, maximum sustainable (i.e., aerobic) swimming speeds, and minimum survivable oxygen levels for yellowfin and skipjack tunas. Results from the model indicate that the cardiorespiratory system of tunas is capable of maximum rates of oxygen delivery, even at low swimming speeds, that are nearly three to five times those of other active teleosts. We believe that, because the pelagic environment provides no place to hide and rest following exhaustive activity, the ability of the cardiorespiratory system of tunas to deliver oxygen to the tissues at high rates evolved for the rapid repayment of oxygen debts rather than to permit exceptionally high sustained swimming speeds.

Conte, F. P., K. Takano, A. Takemura, and G. W. Boehlert. 1991. Ontogeny of the sodium pump in embryos of rockfish of the genus *Sebastes*. *In*: Boehlert, G. W., and J. Yamada (eds.), Rockfishes of the genus *Sebastes*: their reproduction and early life history. Environ. Biol. Fish. 30(1-2):127-134.

The purpose of the present investigation was to determine at what stages of embryonic development the sodium pump (Na+, K+ -activated ATP phosphohydrolase, EC 3.6.1.3) appears and whether the ontogeny of the sodium pump plays a role in the matrotrophic viviparity of *Sebastes*. Early larval stages (stages 1-14) had embryonic tissues nearly devoid of Na, K-ATPase activity. After epiboly, tissues from embryos taken from both species, *S. schlegeli* and *S. taczanowskii*, had significant levels of enzymatic activity coincident with the appearance of neuronal tissue in the head fold (stages 15-20). Maximal levels of specific activities of the enzyme were reached with the onset of the vascular circulation and the opening of the buccal cavity together with maturation of the midgut and hindgut regions of the intestinal tract (stages 26 and 28). Ouabain, a specific inhibitor of Na, K-ATPase, was used to measure survival of embryos placed in different seawater concentrations under in vitro con-

ditions. The most sensitive stages to external ouabain were 26-30. These findings support the hypothesis that the intestinal tract is functional prior to gestation and could be transporting important nutritive material found in maternal ovarian fluid.

Eldridge, Maxwell B., Jeannette A. Whipple, Michael J. Bowers, Brian M. Jarvis, and Jordan Gold. 1991. Reproductive performance of yellowtail rockfish, *Sebastes flavidus*. Environ. Biol. Fish. 30:91-102.

Field and laboratory studies were conducted for 3 years on the yellowtail rockfish, *Sebastes flavidus*, from Cordell Bank, California, in order to characterize the reproduction of this species whose northern stocks have declined. Research findings included reversal of the sex ratios and male-female ages and sizes at age throughout the annual cycle, heavier and longer females at age than males after sexual maturation, maturation of females at 6 and males at 8 years, long reproductive lifespans, distinct male and female gonadosomatic index patterns over the annual cycle, age-and size-specific fecundity, no difference between potential and realized fecundity and the seasonal changes associated with gonadogenesis. The reproductive profile of the Cordell Bank yellowtail rockfish provided a base for comparison with northern populations that appeared to differ, especially in age and size.

Gerrodette, Tim and William G. Gilmartin. 1990. Demographic consequences of changed pupping and hauling sites of the Hawaiian monk seal. Conserv. Biol. 4(4):423-430.

During the last 30 years, changes in the size of Hawaiian monk seal populations at several locations have been associated with the amount and type of human disturbance. Recreational beach activities caused monk seals to alter their pupping and hauling patterns. Survival of pups in suboptimal habitats was low, leading to gradual population declines. During the last decade at Kure Atoll, the process has been reversed: human disturbance on beaches has decreased, and traditional pupping and hauling sites have been reestablished. Subsequently, high survival rates of young seals, coupled with two successful enhancement programs for female pups, have led to dramatic changes in the age and sex composition of the population. Based on these changes, the monk seal population at Kure Atoll soon should begin to increase. Apparently small behavioral changes in such vital activities as feeding and reproduction can have large demographic consequences. Therefore, monitoring of endangered species should include data on habitat use and age and sex composition, as well as estimates of abundance.

Henderson, J. R., and M. R. Finnegan. 1990. Population monitoring of the Hawaiian monk seal, *Monachus schauinslandi*, and captive maintenance project at Kure Atoll, 1988. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-150, 24 p.

Data on the Hawaiian monk seal, *Monachus schauinslandi*, were collected at Kure Atoll from 23 February to 20 October 1988. Beach counts made on 54 atoll-wide censuses averaged 30.0 seals, including pups of the year. Eight pups (five females and three males) were born; seven survived to weaning. Thirteen injuries to 12 seals were documented, and 5 seals became entangled in marine debris. An estimated 1,195 kg of debris were removed from beaches. Thirty-two of 40 seals tagged at Kure Atoll since 1981 were resighted. Five weaned female pups were maintained in a protective enclosure until 20-21 September, and a yearling Kure Atoll seal, which had been rehabilitated in Honolulu, was maintained in the enclosure from 22 March to 12 May.

Hightower, Joseph E. 1990. Multispecies harvesting policies for Washington-Oregon-California rockfish trawl fisheries. Fish. Bull., U.S. 88:645-656.

Optimal harvesting policies were developed for a model of the Washington-Oregon-California trawl fisheries for bocaccio *Sebastes paucispinus*, chilipepper *S. goodei*, widow rockfish *S. entomelas*, splitnose rockfish *S. diploproa*, and shortbelly rockfish *S. jordani*. In the simulated management system, the annual quota for each species was based on an intended fishing mortality rate (F) and an estimate of stock biomass. Traditional constant F policies were compared with variable F policies in which F was a linear function of either stock biomass (single-species) or the combined biomass of all other species (multispecies). Variable F policies were ineffective for increasing total harvest of all species combined, when compared with constant F policies. However, both single-species and multispecies variable F policies were found to reduce the variance for total harvest substantially with no significant loss in yield. The reduction in variance was roughly equal to the reduction that would be achieved by lowering the coefficient of variation (CV) for biomass estimates from 50% to 25% or from 25% to 0%. The reduction in variance generally was greater for the multispecies than for the single-species variable F policy. Compared with the case where CV=0%, average total yield was reduced slightly for both constant F and variable F policies when CVs for biomass estimates were greater than 0%.

Holland, K. N., R. W. Brill, and R. K. C. Chang. 1990. Horizontal and vertical movements of Pacific blue marlin captured and released using sport fishing gear. Fish. Bull., U.S. 88:397- 402.

Holland, K. N., R. W. Brill, and R. K. C. Chang. 1990. Horizontal and vertical movements of yellowfin and bigeye tunas associated with fish aggregating devices. Fish. Bull., U.S. 88:493-507.

The horizontal and vertical movements of yellowfin tuna *Thunnus albacares* and bigeye tuna *T. obesus* captured near fish- aggregating devices (FADs) were determined using pressure-sensitive ultrasonic transmitters. The movements of these FAD-associated fish

were compared with the tracks of yellowfin tuna not associated with FADs. Tracks from 11 yellowfin and 4 bigeye tuna were obtained; these included 23 complete 24-hour periods of observation. Whether associated with FADs or a 40-fathom (75-m) reef dropoff, most yellowfin and bigeye tunas exhibited similar diurnal patterns. The fish tended to remain tightly associated with FADs or the reef dropoff during the day, move away at night, and return the next morning. The maximum range of these nighttime excursions averaged approximately 5 nmi. These tunas apparently treated the FADs as outliers of the coastal topography. This may not be the same behavior that results in the association of these species with drifting objects such as logs. Tuna can learn FAD positions and navigate precisely between FADs that are at least 10 nmi apart. When not associated with FADs or the 40-fathom dropoff, yellowfin tuna oriented to the bottom of the mixed layer (50-90 m) in daytime, whereas the bigeye occupied depths between 190 and 250 m. The daytime distribution of bigeye tuna seemed to be influenced by the depth of the 15°C isotherm. Both species swam closer to the surface at night. Swimming strategies possibly associated with energy and thermoconservation were observed.

Lenarz, William H. and Tina Wyllie Echeverria. 1991. Sexual dimorphism in *Sebastes*. Environ. Biol. Fish. 30:71-80.

Sexual dimorphism and factors that may cause it were investigated in 34 species of the genus *Sebastes*. Sexual dimorphism in standard length and morphometric characters are fairly common in rockfish. In many species males are shorter than females. However in males head length, width of orbit, interorbital width, length of upper jaw, longest pectoral fin ray and longest dorsal spine tend to be larger at a specified size than in females. Water-column species tend to be more dimorphic than demersal species. We suggest that the observed differences in dimorphism in standard length may be related to differences in mating and territorial behavior. Dimorphisms in morphometric measurements may be related to compensation in feeding ability for reduced standard length of males, mating and territorial behavior.

Moser, H. G., and G. W. Boehlert. 1991. Ecology of pelagic larvae and juveniles of the genus *Sebastes*. *In*: Boehlert, G. W., and J. Yamada (eds.), Rockfishes of the genus *Sebastes*: their reproduction and early life history. Environ. Biol. Fish. 30(1-2):203-224.

Pelagic larvae and juveniles of the genus *Sebastes* are widely distributed in the continental shelf and slope waters of subarctic to temperate oceans, with greatest abundance in the Northern Hemisphere. We review the ecology and distribution of these planktonic and micronektonic life stages in relation to oceanographic conditions. Special attention is paid to the west coast of North America, where abundance of larvae from samples collected during 1951-1981 is described. After transformation, the pelagic juveniles are widely distributed, often at great distances form benthic adult habitats. These stages are most frequently distributed in either midwater or near-surface habitats; this dichotomy may require different strategies for successful recruitment.

Mundy, B. C. 1990. Book review: The larvae of Indo-Pacific shorefishes, by Jeffrey M. Leis and Thomas Trnski. Copeia 1990:1196-1198.

Parks, Wesley W., Patricia J. Donley, and Samuel F. Herrick, Jr. 1990. U.S. trade in tuna for canning, 1987. Mar. Fish. Rev. 52(1):14-22.

Pooley, S. G. 1990. Limited entry and Hawaii's fisheries interaction problem. (Abstr.) *In*: C. M. Dewees, and E. Ueber (eds.), Effects of different fishery management schemes on bycatch, joint catch, and discards. Summary of a national workshop sponsored by the California Sea Grant College and the National Marine Fisheries Service, January 20-31, 1990, San Francisco, California, p. 40-41. California Sea Grant College Report No. T- CSGCP-019.

Schwing, Franklin B., Stephen Ralston, David M. Husby, and William H. Lenarz. 1990. The nearshore physical oceanography off the central California coast during May-June 1989: a summary of CTD data from juvenile rockfish surveys. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-153, 10 p.

Seeb, L. W., J. E. Seeb, and J. J. Polovina. 1990. Genetic variation in highly exploited spiny lobster, *Panulirus marginatus*, populations from the Hawaiian Archipelago. Fish. Bull., U.S. 88:712-718.

Spiny lobsters *Panulirus marginatus* from the Hawaiian Archipelago have undergone heavy fishing pressure since 1980 and have experienced increases in asymptotic length and decreases in mean length at onset of egg production. Prior to the expansion of the fishery, allozyme variation was surveyed, and populations were found to be polymorphic at seven loci. In 1987 we collected spiny lobsters from two of the previously sampled locations (Necker Island and Maro Reef) to test for significant changes in population structure or level of genetic variability. No significant changes through time were found at five of the seven loci. Significant differences were detected at *Est3* and *EstD*; however, frequencies at esterase loci have been previously shown to fluctuate through time. Observed number of allelic classes and observed heterozygosities have remained unchanged. The data suggest that no change in the amount of variability has occurred in spiny lobster since the expansion of the fishery.

Shimizu, M., M. Kusakari, M. M. Yoklavich, G. W. Boehlert, and J. Yamada. 1991. Ultrastructure of the epidermis and digestive tract in *Sebastes* embryos, with special reference to the uptake of exogenous nutrients. *In*: Boehlert, G. W., and J. Yamada (eds.), Rockfishes of the genus *Sebastes*: their reproduction and early life history. Environ. Biol. Fish. 30(1- 2):155-164.

Ultrastructural features of the epidermis and rectum were studied in *Sebastes schlegeli* and *S. melanops* during the late stages of embryonic development, to confirm uptake of maternal substances. Ruthenium red (RR) and horseradish peroxidase (HRP) were used at fixation and in live embryos, respectively. Epidermal tissue of embryos after developmental stage 24 comprised two squamous cell layers. The outer, thinner cells and their intercellular spaces were easily infiltrated with RR, but the inner cells had no RR deposition. The HRP was not incorporated into the epidermis except in a few outer cells, which had well-developed microvillous projections of cytoplasm. Sacciform cells, chloride cells, and mucous cells distributed in the inner layer but protruding to the epidermal surface had no intracellular RR and HRP depositions. The rectal cells of embryos at about developmental stage 28 had many globular inclusions containing electron-dense substances. The rectal cells were found to take up and digest HRP actively. It is suggested that the embryonic epidermis is structurally loose and takes up low weight molecules, while rectal cells, after the opening of the mouth, actively ingest exogenous, high weight molecules.

Wilson, C. D., and G. W. Boehlert. 1990. The effects of different otolith ageing techniques on estimates of growth and mortality for the splitnose rockfish, *Sebastes diploproa*, and canary rockfish, *S. pinniger*. Calif. Fish Game 76:146-160.

Different ageing techniques affect not only the estimates of length at age but also estimates of population growth and mortality rates. This study considers these effects for the splitnose rockfish, *Sebastes diploproa*, and canary rockfish, *S. pinniger*, based on ages determined from the surfaces and sections of otoliths collected during a trawl survey off the west coast of North American in 1980. Estimates of growth based on surface rather than section ages were nearly identical for *S. diploproa* but were higher for *S. pinniger*; slightly different whole otolith ageing techniques are suspected of producing these interspecific differences. For both species, however, estimates of mortality were reduced by more than half when section rather than surface ages were used.

Yoklavich, M. M., and G. W. Boehlert. 1991. Uptake and utilization of ^{14}C-glycine by embryos of *Sebastes melanops*. *In*: Boehlert, G. W., and J. Yamada (eds.), Rockfishes of the genus *Sebastes*: their reproduction and early life history. Environ. Biol. Fish. 30(1-2):147-153.

The ability of embryos of the viviparous scorpaenid *Sebastes melanops* to take up nutrients from an exogenous substrate was demonstrated by incubating embryos at various stages of development (18-30 days after fertilization) in ^{14}C-labeled glycine for 24 h. Uptake was highest for embryos at the latest stages (28-30 days) and increased at linear rate during the incubation period. Nutrient uptake was not time dependent in embryos at the early stages (18-22 days). Nutrient utilization by *S. melanops* embryos was measured by the oxidation of ^{14}C-labeled glycine to $^{14}CO_2$. The amount of respired $^{14}CO_2$ by the oldest embryos increased significantly at a linear rate over the 24 h incubation period. There was no evidence of nutrient utilization by the youngest embryos. The developmental changes we observed in the uptake and utilization of exogenous glycine are supported by our previous findings that the oldest embryos have fully developed mouths and guts, and required additional nutrition from intraovarian sources at this stage of development.

Approved by Science and Research Director

Ainley, D. G., W. J. Sydeman, R. H. Parrish, and W. H. Lenarz. Ocean advection and the distribution of juvenile rockfish in central California. For consideration for publication in California Cooperative Oceanic Fisheries Investigation Reports.

Bakun, Andrew. The California Current, Benguela Current, and Southwestern Atlantic Shelf Ecosystems: A comparative approach to identifying factors regulating biomass yields. For publication in The Large Marine Ecosystem (LME) Concept and its Application to Regional Marine Resource Management. (Publ. by AAAS)

Butler, John L. Mortality and recruitment of Pacific sardine, *Sardinops sagax caerulea*, larvae in the California Current. For consideration for publication in the Canadian Journal of Fisheries and Aquatic Sciences.

Dizon, Andrew E., Christina Lockyer, William F. Perrin, Douglas P. DeMaster and Joyce Sisson. Rethinking the stock concept: A phylogeographic approach. For consideration for publication in Conservation Biology.

Lenarz, William H. Shortbelly rockfish. For publication in California's Living Marine Resources and Their Utilization.

Lenarz, William H. Widow rockfish. For publication in California's Living Marine Resources and Their Utilization.

Lenarz, William H., Ralph J. Larson, and Stephen Ralston. An in-depth review of the depth distributions of early life history stages of important fishes of the California Current. For consideration for publication in California Cooperative Oceanic Fisheries Reports.

MacCall, Alec D. Demographic increase in natural mortality rate with age may lead to weak compensation in exploited populations. For consideration for publication in the Journal du Conseil.

Mason, Janet E. The southern California purse seine fishery and the catch of jack mackerel: A meaningful relationship. For consideration for publication in California Cooperative Oceanic Fisheries Investigations Reports.

Parrish, Frank A. and Thomas K. Kazama. Evaluation of ghost fishing in the Hawaiian lobster fishery. For consideration for publication in Fishery Bulletin, U.S.

Perrin, William F. Why are there so many kinds of dolphins: Cetacean diversity and implications for conservation. For consideration for publication in Bioscience (special issue).

Perrin, William F., Alexey V. Yablokov, Jay Barlow, and Mikhail V. Mina. Comparison of the resolving power of metrical and non-metrical cranial characters in defining geographical populations of dolphins. For consideration for publication in Contributions in Science, Natural History Museum of Los Angeles County.

Sakagawa, Gary T. Are U.S. regulations on tuna-dolphin fishing driving U.S. seiners to foreign-flag registry? For consideration for publication in the North American Journal of Fisheries Management.

Schwing, F. B., D. M. Husby, N. Garfield, and D. E. Trach. Mesoscale response of coastal waters off central California to wind effects following the spring 1989 transition: analysis of CTD surveys and AVHRR imagery. For consideration for publication in Calif. Coop. Oceanic Fish. Invest. Rep.

Smith, Susan E. Leopard shark *Triakis semifasciata*. For publication in California Living Marine Resources and Their Utilization.

Administrative Reports

Dizon, Andrew E., Christina Lockyer, William F. Perrin, Douglas P. DeMaster, and Joyce Sisson. 1991. Rethinking the stock concept: A phylogeographic approach. SWFSC Admin. Rep., La Jolla, LJ-91-01.

Dollar, R. A., R. Y. Ito, K. E. Kawamoto, and K. C. Landgraf. 1991. Summary of swordfish longline observations in Hawaii, July-October 1990. SWFSC Admin. Rep., Honolulu, H-91-03, 10 p.

Schug, D. M. 1991. The prospects for an international fisheries management regime for South Pacific albacore. SWFSC Admin. Rep., Honolulu, H-91-02, 31 p.

Translations

Aoki, M., and S. Ueyanagi. 1989. Larval morphology and distribution of the dolphin fishes, *Coryphaena hypurus* and *C. equiselis* (*Coryphaena*). Proceedings of Tokai University, Oceanography Section, 28:157-174. (Engl. transl. by Tamio Otsu, 1991, 24 p., Translation No. 138; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

Greze, N. V., and A. V. Kovalev. 1985. Distribution of plankton in areas of elevations of the ocean bottom. *In*: Vinogradov, M. E., and M. V. Flint (eds.), Biological bases of the commercial exploitation of the open areas of the ocean. Academy of Sciences of the U.S.S.R., Commission on Problems of the World Ocean, p. 204-210. Nauka Publ., Moscow. (Engl. transl. by W. G. Van Campen, 1991, 15 p., Translation No. 135; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

Kanamori, K. 1984. Analysis of fishing effect. *In*: Sato, O. (ed.), Suisangaku Series (Fisheries Series), No. 51, Nihon Suisan Gakkai Kanshu (compilation by Japan Fisheries Society), p. 111-122. Koseisha Koseikaku, Tokyo. (Engl. transl. by Tamio Otsu, 1991, 18 p., Translation No. 136; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

Lanin, V. I. 1985. Oceanic preconditions for the formation of the heightened fish productivity of Antarctic banks. *In*: Vinogradov, M. E., and M. V. Flint (eds.), Biological bases of the commercial exploitation of the open areas of the ocean. Academy of Sciences of the U.S.S.R., Commission on Problems of the World Ocean, p. 210-221. Nauka Publ., Moscow. (Engl. transl. by W. G. Van Campen, 1991, 13 p., Translation No. 132; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

Mironov, A. N. 1985. Sea urchins as possible indicators of aggregations of benthopelagic fishes over the summits of submerged oceanic elevations. *In*: Vinogradov, M. E., and M. V. Flint (eds.), Biological bases of the commercial exploitation of the open areas of the ocean. Academy of Sciences of the U.S.S.R., Commission on Problems of the World Ocean, p. 231-236. Nauka Publ., Moscow. (Engl. transl. by W. G. Van Campen, 1991, 8 p., Translation No. 137; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

Sato, O., and M. Sakuda. 1984. Efficacy of oceanic structures, particularly the artificial reefs, *In*: Marumo, R. (ed.), Biological process in the ocean (Kaiyo no seibutsu katei), p. 430-433. Koseisha Koseikaku, Tokyo. (Engl. transl. by Tamio Otsu, 1991, 7 p., Translation No. 133; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

Tameishi, H., and H. Shinomiya. 1989. Formation of southbound skipjack fishing grounds and its discriminant prediction off Touhoku Sea area. Nippon Suisan Gakkaishi 55(4):619-625. (Engl. transl. by Tamio Otsu, 1991, 15 p., Translation No. 134; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

ERRATUM: On page 20 of the November-December 1990 SWFSC Report of Activities, there was a duplication of one paragraph beginning the Groundfish Analysis Investigation section. This should have been deleted.

UNITED STATES
DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SOUTHWEST FISHERIES CENTER
8604 LA JOLLA SHORES DRIVE
P.O. BOX 271
LA JOLLA, CALIFORNIA 92038

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE, $300

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
DEPARTMENT OF COMMERCE
210

THIRD CLASS